DRAFT REPORT

Thorn Creek Watershed Stage 3 TMDL Report

For Public Review

Prepared for Illinois EPA

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Acronyms

ACEP	Agricultural Conservation Easement Program
BMP	best management practice
BOD	biochemical oxygen demand
cfs	cubic feet per second
cfu	colony forming unit
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DAF	design average flow
DMF	design maximum flow
DMR	discharge monitoring report
DO	dissolved oxygen
EQIP	Environmental Quality Incentives Program
FSA	Farm Service Agency
GIS	geographic information system
IDA	Illinois Department of Agriculture
Illinois EPA	Illinois Environmental Protection Agency
LA	load allocation
lbs	pounds
LC	loading capacity
LRS	load reduction strategy
MGD	million gallons per day
mg/L	milligrams per liter
mL	milliliter
MHP	mobile home park
MOS	margin of safety
MS4	municipal separate storm sewer system
MWRD	Metropolitan Water Reclamation District of Greater Chicago
NMP	Nutrient Management Plan
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NVSS	non-volatile suspended solids
POTW	publicly owned treatment work
RC	reserve capacity
SARE	Sustainable Agricultural Grant Program
SOD	sediment oxygen demand
SSRP	Streambank Stabilization and Restoration Program
STP	sewage treatment plant
SWCD	Soil and Water Conservation District
TMDL	total maximum daily load
TRM	turf reinforcement mat
TSCD	Thorn Creek Sanitary District
TSS	total suspended solids
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency

USGS	U.S. Geological Survey
WLA	waste load allocation
WWTF	wastewater treatment facility
WWTP	wastewater treatment plant
WREP	Wetland Reserve Enhancement Partnership

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Section 1

Methodology Development for the Thorn Creek Watershed

1.1 Total Maximum Daily Load Overview

A total maximum daily load, or TMDL, is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDLs are a requirement of Section 303(d) of the Clean Water Act (CWA). To meet this requirement, the Illinois Environmental Protection Agency (Illinois EPA) must identify water bodies not meeting water quality standards and then establish TMDLs for restoration of water quality. Illinois EPA develops a list known as the "303(d) list" of water bodies not meeting water quality standards every two years, and it is included in the Integrated Water Quality Report. Water bodies on the 303(d) list are then targeted for TMDL development. The Illinois EPA's most recent Integrated Water Quality Report was submitted to the United States Environmental Protection Agency (USEPA) in July 2016. In accordance with USEPA's guidance, the report assigns all waters of the state to one of five categories. 303(d) listed water bodies make up category five in the integrated report (Appendix A of the Integrated Report).

In general, a TMDL is a quantitative assessment of water quality impairments, contributing sources, and pollutant reductions needed to attain water quality standards. The TMDL specifies the amount of pollutant or other stressor that needs to be reduced to meet water quality standards, allocates pollutant control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a waterbody.

Water quality standards are laws or regulations that states authorize to enhance water quality and protect public health and welfare. Water quality standards provide the foundation for accomplishing two of the principal goals of the CWA. These goals are:

- Restore and maintain the chemical, physical, and biological integrity of the nation's waters
- Where attainable, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water

Water quality standards consist of three elements:

- The designated beneficial use or uses of a waterbody or segment of a waterbody
- The water quality criteria necessary to protect the use or uses of that particular waterbody
- An antidegradation policy

Examples of designated uses are primary contact (swimming), protection of aquatic life, and public and food processing water supply. Water quality criteria describe the quality of water that will support a designated use. Water quality criteria can be expressed as numeric limits or as a narrative statement. Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected.

1.2 TMDL Goals and Objectives for the Thorn Creek Watershed

The Illinois EPA has a three-stage approach to TMDL development. The stages are:

Stage 1 – Watershed Characterization, Data Analysis, Methodology Selection

Stage 2 – Data Collection (optional)

Stage 3 – Model Calibration, TMDL Scenarios, Implementation Plan

TMDL development for this watershed began in 2008. Stage 1 was updated in 2011 under a contract with AECOM (*Thorn Creek Watershed TMDL Stage 1 Report*, AECOM 2011). Stage 2 data collection was recommended as a result of the Stage 1 reporting process, and additional water quality data were collected for a range of parameters at Sauk Trail Lake as part of the Stage 2 effort in 2008. Additional water quality data were collected and gathered by Illinois EPA, the Metropolitan Water Reclamation District of Greater Chicago (MWRD), and Thorn Creek Sanitary District (TCSD) during the time between the completion of Stage 1 and the commencement of Stage 3. All newly available data were assessed and incorporated into this Stage 3 report as appropriate.

The Thorn Creek watershed is comprised of 10-digit Hydrologic Unit Code (HUC-10) 0712000302, which includes four 12-digit subbasins (HUC-12): 071200030201 (Deer Creek), 071200030202 (Butterfield Creek), 071200030203 (North Creek), and 071200030204 (Thorn Creek). The following are the impaired waterbody segments in the Thorn Creek watershed:

- Thorn Creek (HBD-02)
- Thorn Creek (HBD-03)
- Thorn Creek (HBD-04)
- Thorn Creek (HBD-05)
- Thorn Creek (HBD-06)
- North Creek (HBDA-01)
- Butterfield Creek (HBDB-03)
- Deer Creek (HBDC)
- Deer Creek (HBDC-02)
- Sauk Trail Lake (RHI)

These impaired waterbody segments are shown on **Figure 1-1**. There are ten impaired waterbody segments within the watershed for which TMDL and/or a load reduction strategy (LRS) development was initiated in 2008. **Table 1-1** lists the waterbody segment and cause of impairment for the waterbody.

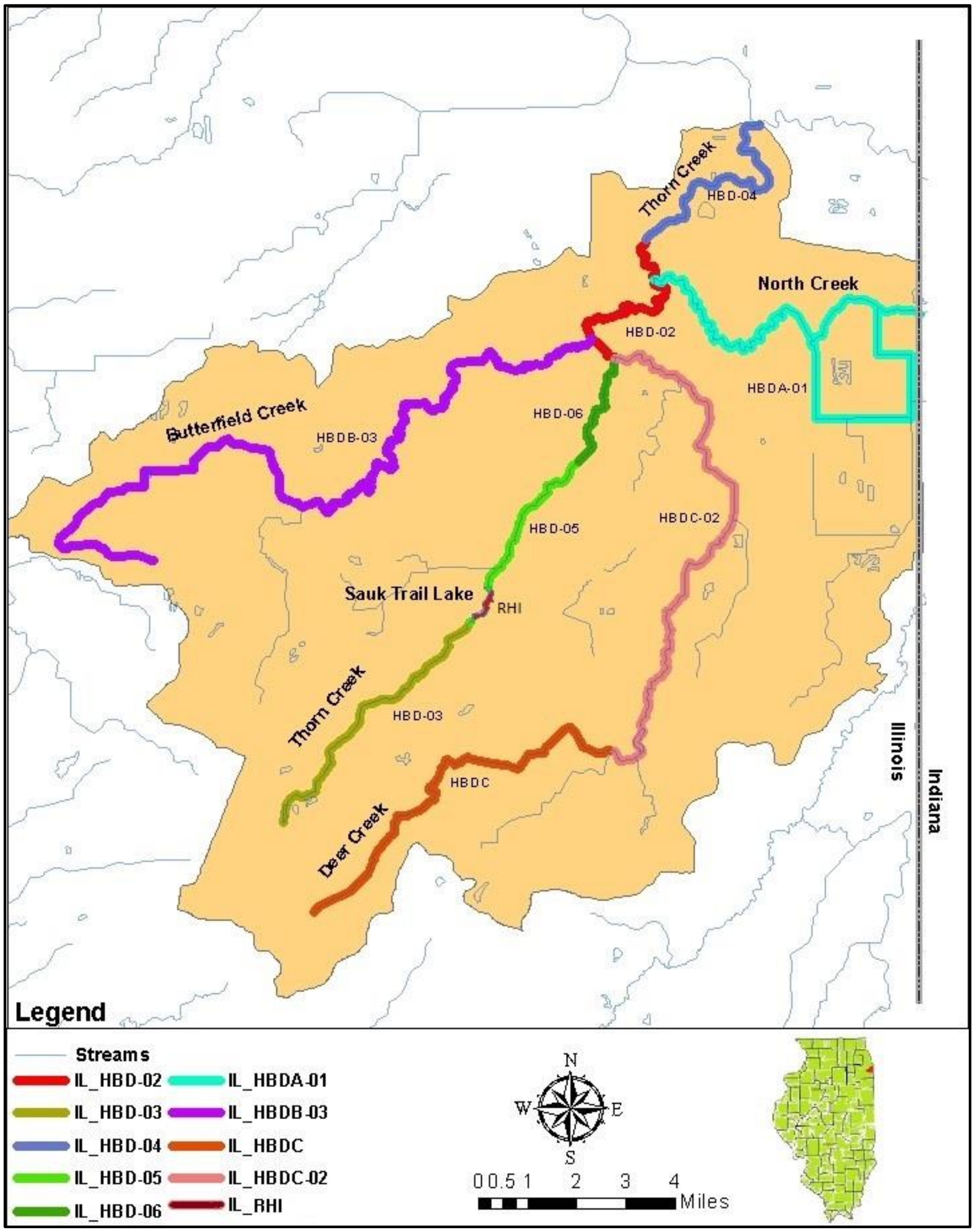


Figure 1-1: Impaired Waterbody Segments in Thorn Creek Watershed

Table 1-1: Waterbodies and Impairments Originally Targeted for TMDL and LRS Development in the Thorn Creek Watershed (based on the 2008 303(d) list)

Segment ID	Waterbody Name	TMDL Parameter	LRS Parameter
HBD-02	Thorn Creek	**Dissolved Oxygen, Fecal Coliform, Silver, Zinc**	*Phosphorus, TSS*
HBD-03	Thorn Creek	**Dissolved Oxygen, Fecal Coliform**	
HBD-04	Thorn Creek	**Dissolved Oxygen, Fecal Coliform, Chloride**	*Phosphorus*
HBD-05	Thorn Creek	**Fecal Coliform**	*Phosphorus*
HBD-06	Thorn Creek	**Dissolved Oxygen, Fecal Coliform, Chloride**	*Phosphorus*
HBDA-01	North Creek	**Dissolved Oxygen**	*Sedimentation/Siltation*
HBDB-03	Butterfield Creek	**Fecal Coliform**	
HBDC	Deer Creek	**Fecal Coliform**	*Phosphorus*
HBDC-02	Deer Creek	**Dissolved Oxygen, Fecal Coliform**	*Phosphorus, Sedimentation/Siltation*
RHI	Sauk Trail Lake	**Phosphorus, Dissolved Oxygen[1]**	*Sedimentation/Siltation, TSS*

[1] Dissolved oxygen impairment addressed through established linkage to total phosphorus impairment.

It should be noted that a small portion, less than 5%, of the Thorn Creek Watershed is in the state of Indiana. This area has no current impairments based on the Indiana 303(d) list or TMDLs developed for it. Load allocations are not assigned for locations outside of the state of Illinois in this TMDL report.

It should be noted that Sauk Trail Lake (RHI) is scheduled to have its dam removed in 2021-2022, by the US Army Corp of Engineers. Since the lake was created by damming Thorn Creek, removing the dam should effectively eliminate Sauk Trail Lake. The dam removal is expected to result in a host of positive environmental impacts, including ecosystem restoration and correcting habitat damage. When the dam is removed, the TMDL for Sauk Trail Lake will no longer be relevant.

The Stage 1 report was developed without investigating impairments caused by parameters without numeric water quality standards (sedimentation/siltation, TSS, and phosphorus in streams). Illinois EPA has previously only developed TMDLs for parameters that have numeric water quality standards while deferring development of TMDLs for parameters without numeric water quality standards until those criteria have been developed and adopted. As part of the TMDL development process, Illinois EPA started to include LRSs in TMDL watershed projects in 2012 for those pollutants that do not currently have numeric water quality standards.

For potential causes that do not have numeric water quality standards as noted in **Table 1-1**, TMDLs were not developed. However, LRSs (similar to TMDLs) were developed as part of Stage 3 based on target values established by Illinois EPA. In addition, some of these potential causes may

be addressed by implementation of controls for the pollutants with numeric water quality standards.

The TMDLs for the segments listed above specify the following elements:

- Loading Capacity (LC) or the maximum amount of pollutant loading a waterbody can receive without violating water quality standards
- Waste Load Allocation (WLA) or the portion of the TMDL allocated to existing or future point sources
- Load Allocation (LA) or the portion of the TMDL allocated to existing or future nonpoint sources and natural background
- Margin of Safety (MOS) or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality
- Reserve Capacity (RC) or a portion of the load explicitly set aside to account for growth in the watershed, as necessary

These elements are combined into the following equation:

$$\mathbf{TMDL = LC = \Sigma WLA + \Sigma LA + MOS + RC}$$

Developing an LRS involves determining the LC and load reduction that is needed in order for the waterbody to meet "Full Use Support" for its designated uses. In an LRS, the LC is not divided into WLA, LA, or MOS. These TMDL components are represented by one number as a target concentration for load reduction within each unique watershed. The LRS provides guidance (with no regulatory requirements) for voluntary nonpoint source reduction efforts by implementing agricultural and urban stormwater best management practices (BMPs).

TMDL and LRS development also takes into account the seasonal variability of pollutant loads so that water quality standards are met during all seasons of the year. Also, reasonable assurance that the TMDL and LRS targets will be achieved is described in the implementation plan. The implementation plan for the Thorn Creek watershed describes how water quality standards and targets will be met and attained. This implementation plan includes recommendations for implementing point source controls, urban and rural BMPs, cost estimates, institutional needs to implement BMPs and controls throughout the watershed, and a timeframe for completion of implementation activities.

1.3 Existing Data Inventory

Illinois EPA provided project files previously collected and analyzed by AECOM for the Thorn Creek watershed TMDL project completed under the previous consultant's TMDL contract. This dataset included a large number of files containing both water quality data and general watershed data related to the TMDL development process. Versions of several of the water quality models proposed in the Stage 1 report for TMDL development were included in the data transfer. While this dataset provided much of the information necessary to complete Stage 3 of the TMDLs, some level of uncertainty existed as to the completeness and usability of each of the data sources. A review and assessment of the existing dataset was necessary, the results of which are discussed below.

1.3.1 Existing Water Quality Data

Water quality data provided by Illinois EPA included a number of MS Excel files containing water quality data originating from several sources. The bulk of the available water quality data were originally collected by Illinois EPA, MWRD, and TCSD. Based on a review of data summary and progress report documents produced by AECOM during the early stages of Stage 3 development, the original datasets compiled and used by AECOM did not appear to have been provided in full. Therefore, available data sources (Illinois EPA, MWRD, TCSD, etc.) were queried for relevant water quality data to supplement the existing water quality dataset provided.

All data identified were compiled into a watershed-specific database that contains approximately 15,000 sample results for the sampled waterbodies in the Thorn Creek watershed (**Appendix A**). The dataset includes sample results for approximately 70 different parameters, approximately 20 of which were potentially relevant to the TMDL and LRS development process (**Table 1-2**).

A summary of the relevant available data from the dataset compiled from Stage 1 data and additional data queried prior to the current Stage 3 development for each waterbody including period of record, sample count, minimum value, maximum value, and average value is provided in **Table 1-3**.

Table 1-2: List of Parameters Included in the Water Quality Dataset Compiled for the Thorn Creek Watershed

Alkalinity	Phosphorus, Dissolved
Chloride, Total	pH
Chlorophyll a	Silver, Dissolved
Coliform, Fecal	Silver, Total
Depth, Bottom	Solids, Fixed, Total
Depth, Secchi Disk	Solids, Fixed, Volatile
Hardness, Total	Solids, TSS
Nitrogen, Ammonia as NH3	Solids, Suspended, Volatile
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	Zinc, Total
Oxygen, Dissolved	Zinc, Dissolved
Phosphorus, Total	

Table 1-3: Summary of Water Quality Data Reviewed for the Current Stage 3 Database Relevant to TMDL and LRS Development in the Thorn Creek Watershed

Waterbody	Parameter	Units	Period of Record	Sample Count	Min	Max	Average
Thorn Creek, HBD-02	Coliform, Fecal	cfu/100ml	1979-2013	256	10	127,000	6,883
	Hardness	mg/L	1980-2007	272	126	791	374
	Oxygen, Dissolved	mg/L	1979-2013	349	3.3	13.6	8.6
	Solids, TSS	mg/L	2000	24	1.0	105	14
	Silver, Total	µg/L	1981-2007	272	ND	40	2.48
	Zinc, Dissolved	µg/L	1979-2007	214	ND	158	59.6
	Phosphorus, Total	mg/L	1979-2004	228	0.08	18	3.0
Thorn Creek, HBD-03	Coliform, Fecal	cfu/100ml	2004 -2012	155	2	40,000	2,699
	Oxygen, Dissolved	mg/L	2003-2012	202	1.1	17.2	8.3
Thorn Creek, HBD-04	Chloride	mg/L	1999-2013	283	1.6	753	195
	Coliform, Fecal	cfu/100ml	1999-2014	400	0	52,000	2,779
	Oxygen, Dissolved	mg/L	2001-2014	346	2.4	19.2	8.4
	Phosphorus, Total	mg/L	1999-2013	343	0.05	17	1.61
Thorn Creek, HBD-05	Coliform, Fecal	cfu/100ml	1983-2013	118	31	200,000	9,762
	Phosphorus, Total	mg/L	1983-2013	131	0.05	4.1	0.21
Thorn Creek, HBD-	Chloride	mg/L	1970-2012	464	4	722	211
	Coliform, Fecal	cfu/100ml	1970-2013	742	9	350,000	9,521

Waterbody	Parameter	Units	Period of Record	Sample Count	Min	Max	Average
06	Oxygen, Dissolved	mg/L	1970-2013	781	0	17	8.4
	Phosphorus, Total	mg/L	1973-2013	556	0.05	52	4.66
North Creek, HBDA-01	Oxygen, Dissolved	mg/L	1972-2011	50	3.5	16.6	8.4
	Solids, Non-Volatile Suspended[1]	mg/L	2006 & 2011	8	3	117	35.6
Butterfield Creek, HBDB-03	Coliform, Fecal	cfu/100ml	1970-2013	171	0	200,000	11,273
Deer Creek, HBDC	Coliform, Fecal	cfu/100ml	2004-2013	82	57	30,200	2,095
Deer Creek, HBDC-02	Coliform, Fecal	cfu/100ml	1972-2012	224	12	266,000	3,031
	Oxygen, Dissolved	mg/L	1972-2012	323	1.0	17.1	9.2
	Phosphorus, Total	mg/L	1972-2012	159	0.05	5.7	0.69
	Solids, Non-Volatile Suspended[1]	mg/L	2001	2	60	62	61
Sauk Trail Lake, RHI	Depth, Bottom	ft	2008	4	2	3	2.6
	Oxygen, Dissolved	mg/L	2008	7	4.71	9.66	6.12
	Phosphorus, Total	mg/L	2008	4	0.11	0.14	0.12
	Solids, TSS	mg/L	2008	4	35	78	65

[1] Calculated from other measured parameters

1.4 Methodology Overview

Table 1-4 contains information on the methodologies selected and used to develop TMDLs and LRSs for impaired segments within the Thorn Creek watershed.

Table 1-4: Methodologies Used to Develop TMDLs and LRSs in the Thorn Creek Watershed

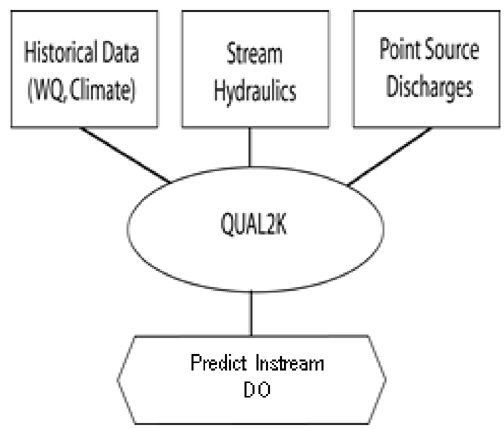
Segment Name/ID	Causes of Impairment	Assessment Type	Methodology
Thorn Creek (HBD-02)	Dissolved Oxygen	TMDL	QUAL2K
	Fecal Coliform	TMDL	Load Duration Curve
	Silver	TMDL	Load Duration Curve
	Zinc	TMDL	Load Duration Curve
	Total Suspended Solids (TSS)	LRS	Load Duration Curve
	Total Phosphorus	LRS	Load Duration Curve
Thorn Creek (HBD-03)	Dissolved Oxygen	TMDL	QUAL2K
	Fecal Coliform	TMDL	Load Duration Curve
Thorn Creek (HBD-04)	Dissolved Oxygen	TMDL	QUAL2K
	Fecal Coliform	TMDL	Load Duration Curve
	Chloride	TMDL	Load Duration Curve
	Total Phosphorus	LRS	Load Duration Curve
Thorn Creek (HBD-05)	Fecal Coliform	TMDL	Load Duration Curve
	Total Phosphorus	LRS	Load Duration Curve
Thorn Creek (HBD-06)	Dissolved Oxygen	TMDL	QUAL2K
	Fecal Coliform	TMDL	Load Duration Curve
	Chloride	No TMDL Developed	No longer impaired – recommended for delisting
	Total Phosphorus	LRS	Load Duration Curve
North Creek (HBDA-01)	Dissolved Oxygen	TMDL	QUAL2K
	Sedimentation/Siltation	LRS	Load Duration Curve (for Nonvolatile Suspended Solids, NVSS)

Segment Name/ID	Causes of Impairment	Assessment Type	Methodology
Thorn Creek	Dissolved Oxygen	TMDL	QUAL2K
Butterfield Creek (HBDB-03)	Fecal Coliform	TMDL	Load Duration Curve
Deer Creek (HBDC)	Fecal Coliform	TMDL	Load Duration Curve
	Total Phosphorus	LRS	Load Duration Curve
Deer Creek (HBDC-02)	Dissolved Oxygen	TMDL	QUAL2K
	Fecal Coliform	TMDL	Load Duration Curve
	Total Phosphorus	LRS	Load Duration Curve
	Sedimentation/Siltation	LRS	Load Duration Curve (for NVSS)
Sauk Trail Lake (RHI)	Total Phosphorus	TMDL	BATHTUB Model
	Dissolved Oxygen	TMDL for Total Phosphorus	
	Sedimentation/Siltation	No LRS Developed[1]	N/A
	TSS	LRS	Spreadsheet Calculation

[1]Insufficient data, current impairment not confirmed

1.4.1 QUAL2K Overview

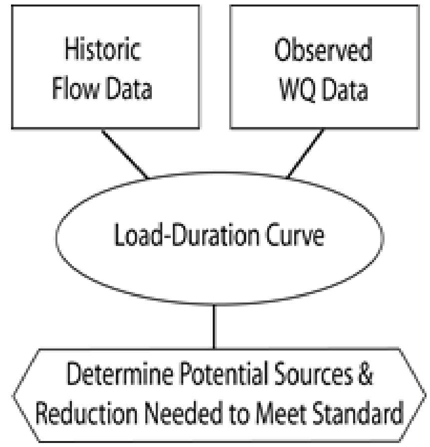
The QUAL2K model was used to develop the dissolved oxygen (DO) TMDL for each of the DO-impaired stream segments in the Thorn Creek watershed (Thorn Creek HBD-02, HBD-03, HBD-04, HBD-06; North Creek HBDA-01; and Deer Creek HBDC-02). QUAL2K is a one-dimensional stream water quality model applicable to well-mixed streams. The model assumes steady state hydraulics and allows for point source inputs, diffuse loading and tributary flows. In general, QUAL2K incorporates historical water quality data, observed hydraulic information, and point source discharge data along with model defaults to predict the resulting instream DO concentrations (see **Schematic 1**).



Schematic 1

1.4.2 Load-Duration Curve Overview

LC analyses were performed for each of the stream segments in this watershed impaired by fecal coliform bacteria, silver, zinc, chloride, total phosphorus, TSS, and sedimentation/siltation through the development of a series of load-duration curves. A load-duration curve is a graphical representation of the maximum load of a pollutant that a stream segment can assimilate over a range of flow scenarios while still meeting the instream water quality standard. The load-duration curve approach utilizes historical flow data and observed water quality data to assess the magnitude and frequency of exceedances as well as to determine the flow scenarios when exceedances occur most often (see **Schematic 2**). In the Thorn Creek watershed, load duration curves were constructed at segments Thorn Creek HBD-02, HBD-03, HBD-04, HBD-05, and HBD-06 and Butterfield Creek HBDB-03 and Deer Creek HBDC and HBDC-02 for fecal coliform; Thorn Creek HBD-02 for silver and zinc; Thorn Creek HBD-04 and HBD-06 for chloride; Thorn Creek HBD-02, HBD-04, HBD-05, and HBD-06 and Deer Creek HBDC and HBDC-02 for total phosphorus; Thorn Creek HBD-02 for TSS; and North Creek HBDA-01 and Deer Creek HBDC-02 for sedimentation/siltation (NVSS).

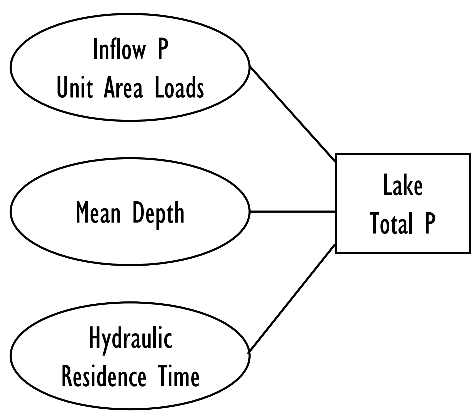


Schematic 2

1.4.3 BATHTUB Overview

The BATHTUB model was used for phosphorus and DO assessments for Sauk Trail Lake. The BATHTUB model performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that accounts for advective and diffusive transport, and nutrient sedimentation. The model relies on empirical relationships to predict lake trophic conditions and subsequent DO conditions as functions of total phosphorus and nitrogen loads, residence time, and mean depth (USEPA 1997). Oxygen conditions in the model are simulated as meta and hypolimnetic depletion rates, rather than explicit concentrations.

TMDL analysis for total phosphorus in Sauk Trail Lake involved the use of observed data coupled with the rational method as inputs to the BATHTUB models. This method required inputs from several sources including online databases and geographic information system (GIS)-compatible data.



Schematic 3

Schematic 3 shows the data inputs for the BATHTUB models that were used to calculate the TMDLs. Subbasin flows were estimated using the area ratio method and phosphorus loadings to each reservoir from the surrounding watersheds were estimated using the unit area load method, also known as the "export coefficient" method (USEPA 2001). This method is based on the assumption that, on an annual basis and normalized to area, a roughly constant runoff pollutant loading can be expected for a given land use type. This method also requires that unit area loads are not applied to watersheds that differ greatly in climate, hydrology, soils, or ecology from those from which the parameters were derived (USGS 1997).

Once the subbasin flows and concentrations were estimated, they were used as input for the BATHTUB models. The BATHTUB model uses empirical relationships between mean reservoir depth, total phosphorus inputted to the reservoir, and the hydraulic residence time to determine in-reservoir concentrations (see Schematic 3).

1.4.4 LRS Overview for TSS and Sedimentation/Siltation in Sauk Trail Lake

A simple spreadsheet approach was used to calculate the reduction in TSS loading into Sauk Trail Lake required to meet the watershed-specific target value established by Illinois EPA of 72.7 milligrams per liter (mg/L). LRS targets are based on data from all stream segments or lakes within the HUC-10 basins of the watershed, as well as stream segments or lakes which closely border the watershed in neighboring HUC-10 basins, in order to best represent the land use, hydrologic, and geologic conditions unique to the watershed. Load reduction targets were calculated by Illinois EPA using data from stream/lake segments whose most current assessment shows full support for aquatic life and data that has passed quality assurance and quality checks within Illinois EPA and are in accordance with state and federal laws.

The LRS calculations utilize the watershed flow estimates similar to those developed as part of the BATHTUB model, the relative proportion of the lake watershed made up by each subbasin, measured in-lake TSS concentrations, and the target value developed by Illinois EPA to calculate the current daily load of TSS into the lake (pounds [lbs]/day), the target load (lbs/day), and the percent reduction needed in order to meet the LRS target. This simplified approach is appropriate for LRS development as it does not require the explicit assessment of WLAs or LAs.

1.5 Methodology Development

The following sections further discuss and describe the methodologies utilized to examine fecal coliform, chloride, total phosphorus, TSS, sedimentation/siltation, silver, zinc and DO levels in the stream segments of the Thorn Creek watershed, as well as total phosphorous, TSS, sedimentation/siltation and DO levels in Sauk Trail Lake.

1.5.1 QUAL2K Model Development

QUAL2K (Q2K) is a river and stream water quality model that is intended to represent a modernized version of the QUAL2E (Q2E) model (Brown and Barnwell 1987). The original Q2E model is well-known and USEPA-supported. The modernized version has been updated to use MS Excel as the user interface and has expanded the options for stream segmentation as well as a number of other model inputs. Q2K simulates DO dynamics as a function of nitrogenous and carbonaceous oxygen demand, atmospheric reaeration, sediment oxygen demand (SOD), and plant photosynthesis and respiration. The model also simulates the fate and transport of nutrients and biochemical oxygen demand (BOD) and the growth and abundance of floating (phytoplankton) and attached (periphyton) algae (as chlorophyll-a). Stream hydrodynamics and temperature are important controlling parameters in the model. Headwater, point source, and non-point source loadings and flows are explicitly input by the user. The model simulates steady-state diurnal cycles. Model parameter default values are provided in the model based on past studies and are recommended in the absence of site-specific information. Along with its capability to aid in DO assessment, Q2K can also be used to model nutrient and pH fluctuations within a stream segment.

All of the stream segments in the Thorn Creek watershed that are impaired for DO adjoin, allowing for a single contiguous Q2K model to be developed capable of modeling all of the impaired segments simultaneously. Because Q2K models simulate steady-state diurnal cycles, the TMDL endpoints used for analysis at each segment were the 7-day average daily minimum water quality standards of 6.0 mg/L (March-July). The use of the 7-day minimum standard as a TMDL endpoint, as opposed to the 5.0 mg/L (March-July) instantaneous minimum standards, serves as a conservative measure adding to the implicit MOS included in the final TMDL calculations for each impaired segment (see further discussion in **Section 2**).

1.5.1.1 QUAL2K Inputs

Table 1-5 contains the categories of data required for the Q2K models along with the sources of data used to analyze each of the impaired stream segments in the Thorn Creek watershed.

Table 1-5: Q2K Data Inputs

Input Category	Data Source
Stream Segmentation	GIS data
Hydraulic characteristics	Aerial photographs; GIS; Illinois EPA field data
Headwater conditions	Historic water quality data
Meteorological conditions	National Climatic Data Center
Point Source contributions	Illinois EPA, USEPA's Permit Compliance System and Integrated Compliance Information System

Empirical data amassed during Stage 1 of TMDL development were used to build the Q2K models.

1.5.1.2 Stream Segmentation

The Q2K model represents a river as a series of reaches. Each reach shares constant channel geometry and hydraulic characteristics. Each TMDL segment was represented by one or more Q2K model segments, each of which was further divided into many computational units.

The modeled Thorn Creek system includes one first order tributary (Thorn Creek), divided into six reaches, and three tributaries. The tributary stream segments were divided into a total of eight reaches in the model: two reaches for North Creek, three reaches for Butterfield Creek, and three reaches for Deer Creek. A total of 54.2 river miles were included in the model: 6.6 miles of North Creek, 14.7 miles Butterfield Creek, 15.8 miles of Deer Creek, and 17.1 miles of the mainstem. **Figure 1-2** shows the stream segmentation used for the Thorn Creek Q2K model.

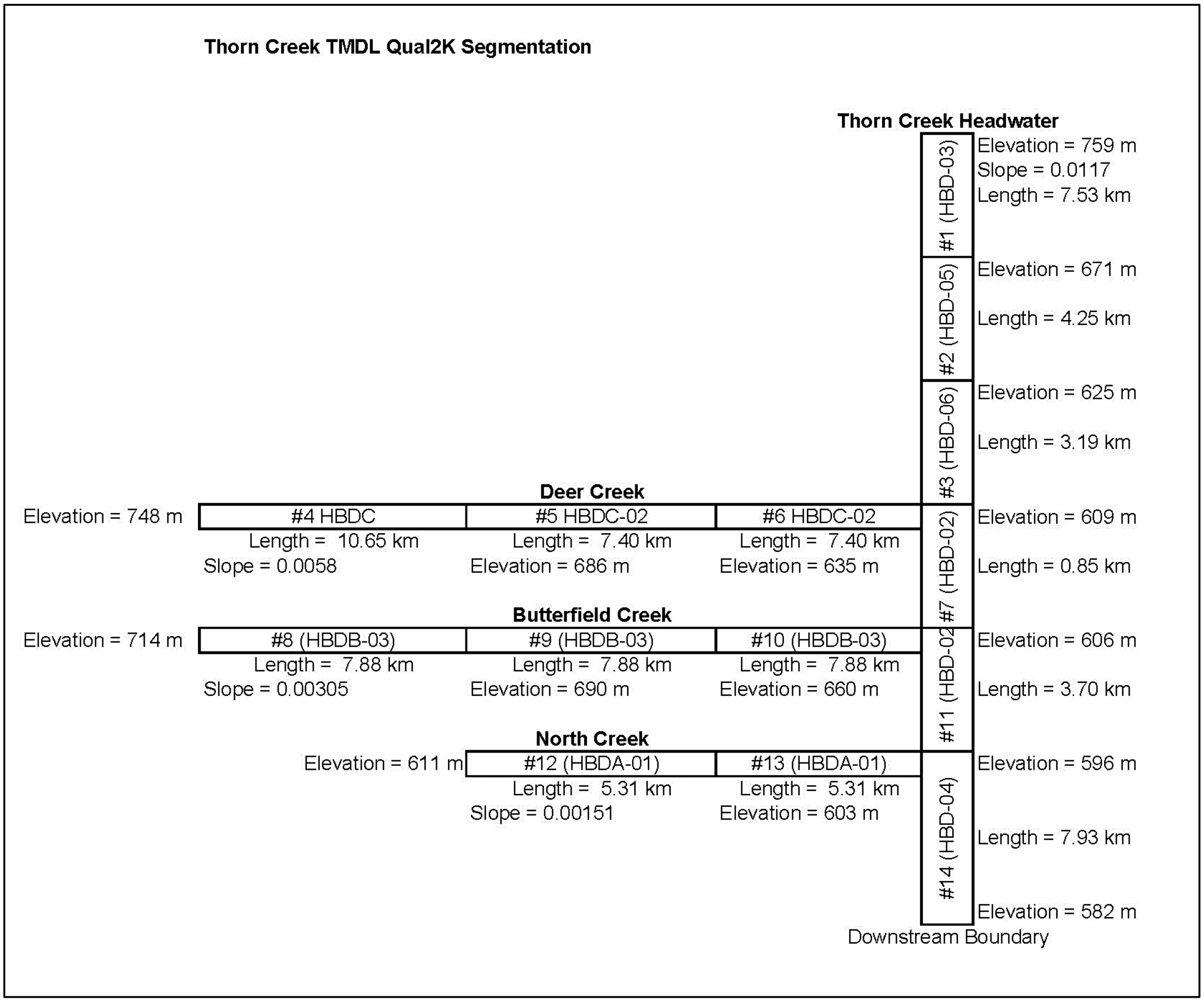


Figure 1-2: Stream Segmentation Used for the Thorn Creek Qual2K Model

1.5.1.3 Flow and Hydraulic Characteristics

Flow rates for the modeled period were set in the model based on measured flows at a series of U.S. Geological Survey (USGS) flow gauges distributed throughout the modeled basin. The following gauges were used to support the modeling (**Figure 1-3**): 05536215 (Thorn Creek at Glenwood), 05536235 (Deer Creek near Chicago Heights), 05536255 (Butterfield Creek at Flossmoor), 05536265 (Lansing Ditch near Lansing), and 05536275 (Thorn Creek at Thornton). The majority of stream hydraulic data specified in the model is based on physical stream characteristic data collected during an additional Illinois EPA field survey conducted in September 2007 under relatively low-flow conditions.

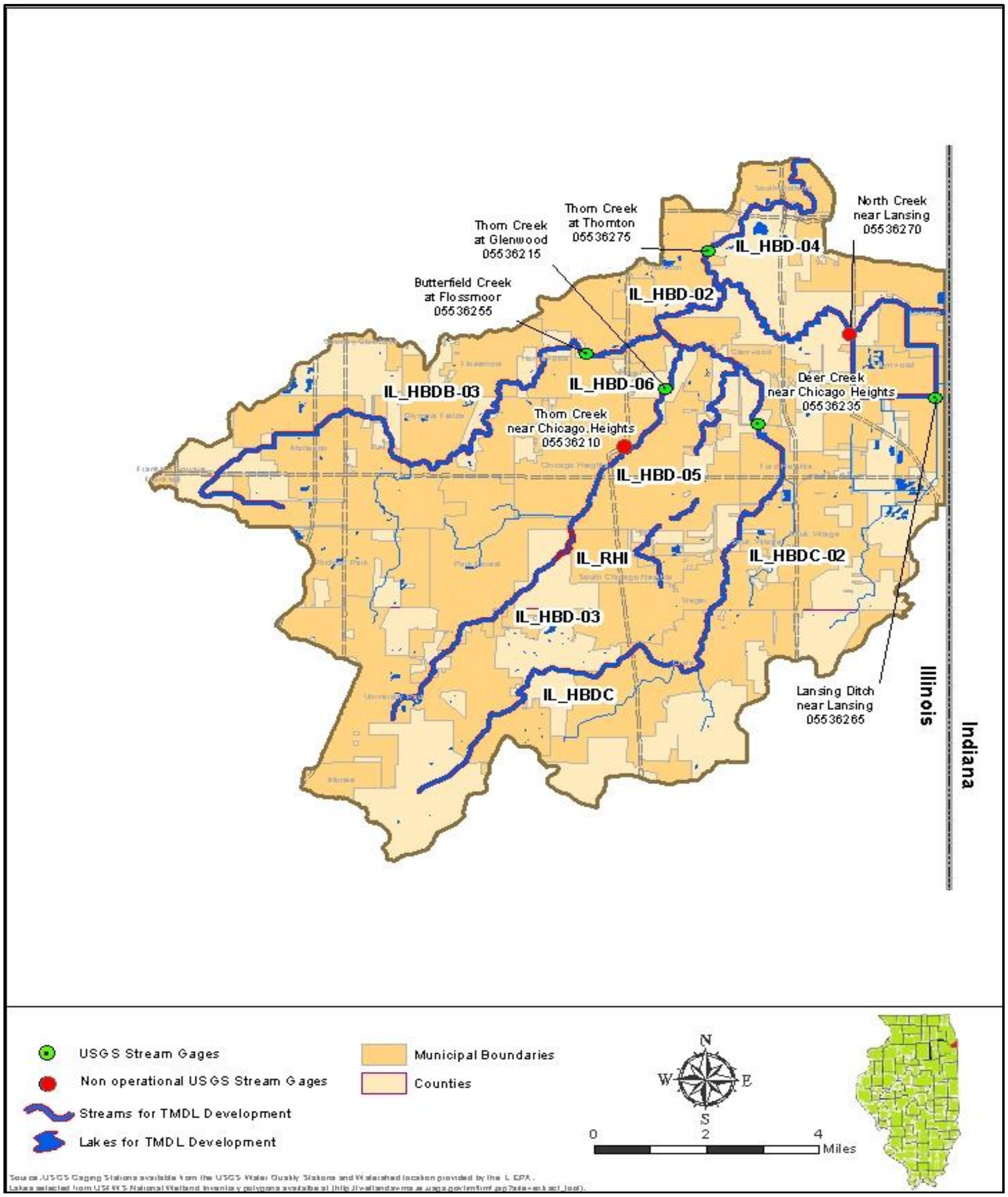


Figure 1-3: USGS Stream Gages in Thorn Creek Watershed

1.5.1.4 Headwater Conditions

Separate headwater conditions were established for each of the four upper reaches of the Thorn Creek watershed (Thorn Creek, Butterfield Creek, Deer Creek, and North Creek). Headwater water quality conditions were set based on available in-stream water quality data for July 6, 2005, as this represents the most recent date within the critical period for DO assessment (late in the growing season and under low flows) for which water quality data collected at multiple locations across the modeled system were available. Headwater flows were also estimated using area-weighting of available stream gauge data for July 6, 2005.

1.5.1.5 Diffuse Flow

Diffuse flow gains were assumed for the Thorn Creek reaches based on flow balance calculations that included USGS flow gauge and point source discharge (described below) information. As with the headwater flow calculations, area-weighting calculations were used to estimate flow gains, exclusive of point sources, at additional locations throughout the system. These flows were included in the model as diffuse inputs to the system.

1.5.1.6 Climate

Q2K requires inputs for climate, as they pertain to the calculation of water temperature and reaeration. Temperature and wind speed data for the synoptic sampling date were obtained from the National Climatic Data Center. Data from the nearest available weather stations (Lansing Municipal Airport and NOAA Weather Station IL116616 in Park Forest, IL) were used for the model.

1.5.1.7 Point Sources

Two major and three minor National Pollutant Discharge Elimination System (NPDES) permitted point source dischargers with reported discharges during the model simulation period were included in the model. Additional NPDES permitted discharges in the watershed, such as the Park Forest Excess Flow Facility (IL0047562) and several stormwater discharge permitees which only discharge under high flow conditions, do not discharge during the critical low flow period and were therefore not included in the critical condition model. Q2K allows user input of point source locations, flow, and water quality data. Permit records were reviewed and reported discharge data were used for model input. Where necessary concentration data were not available, estimates based on other facilities in the watershed and waterbody data were used to develop approximated model inputs. **Table 1-6** contains final model input information for each facility, including average flow for each facility in million gallons per day (MGD). The locations of each facility are shown in **Figure 1-4**. Flow information was available for each discharger; however, permit limit concentration data are available only for parameters that are sampled per permit requirements.

Table 1-6: Point Source Discharge Model Inputs for Thorn Creek QUAL2K Models

Facility Name	Permit Number	Average Facility Flows (MGD)	Receiving Segment	DO Model Input (mg/L)	CBOD (mg of O2/L)	Ammonia N (mg/L)
Aqua Illinois – University Park WWTF	IL0024473	2.43	Deer Creek	6.7	1.4	0.30
Mid-West Manufacturing LLC	IL0059421	0.00013	Thorn Creek	7.0		
Paradise Park MHP	IL0026794	0.064	North Creek	7.0	2.0	0.28
Innophos Inc.	IL0035220	0.27	Thorn Creek	7.0		
Thorn Creek Basin Sanitary District STP	IL0027723	15.94	Thorn Creek	6.3	2.0	0.50
Chicago Heights Steel	IL0001678	Intermittent	Thorn Creek	7.0	23.0	

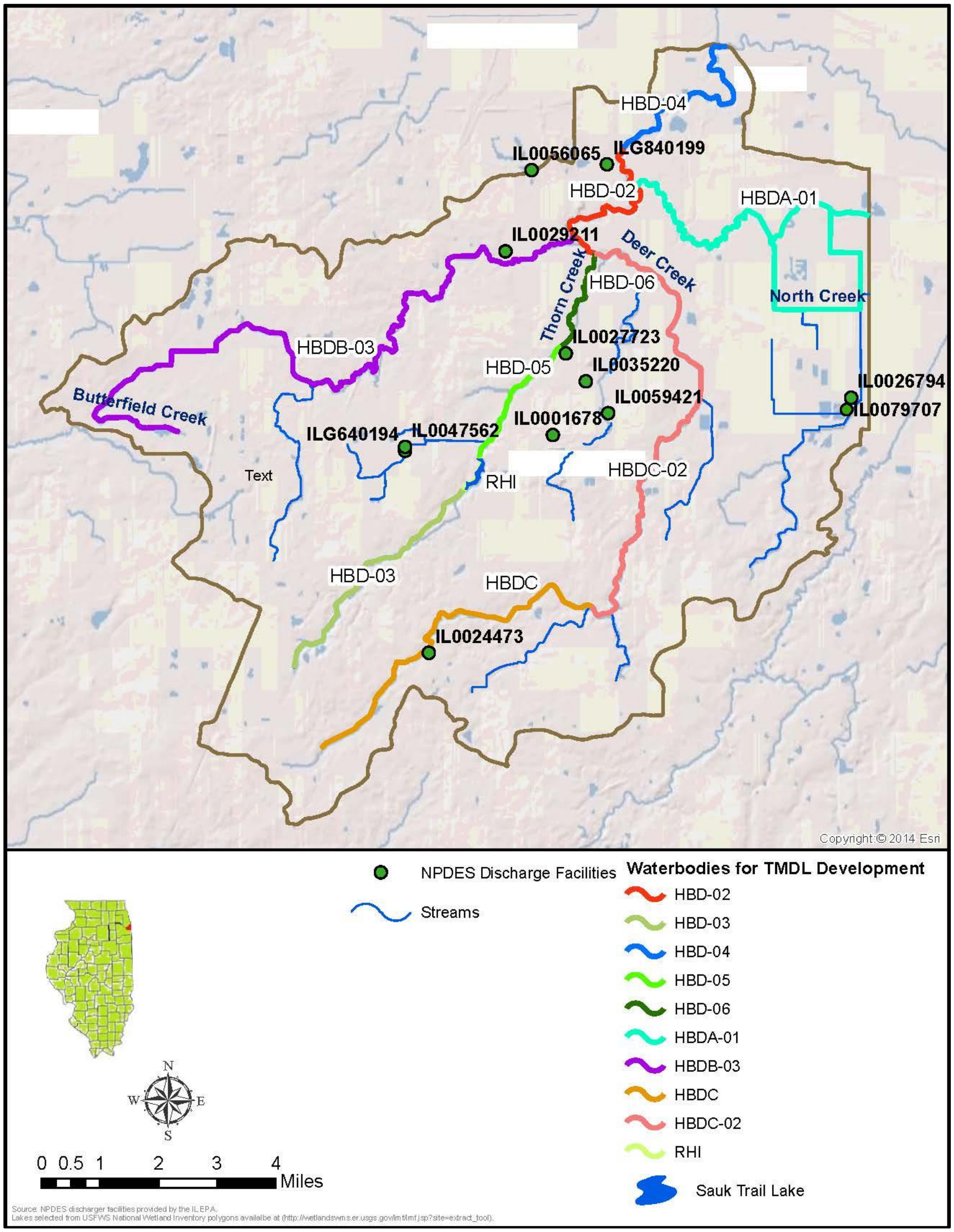


Figure 1-4: Point Source Dischargers in Thorn Creek Watershed

1.5.1.8 QUAL2K Calibration

Sufficient water quality data were available to perform an approximate calibration of the model kinetic and transport rates. A synoptic data set, spatially distributed data obtained on the same day, was available for a low flow period on July 6, 2005. This data set was used to calibrate key model kinetic parameters and reach hydraulics. This calibration day can be considered representative of critical conditions with respect to DO, as it was during a period of low flows and high temperatures. The river was effluent dominated during this low flow period. Measured DO levels for this day were consistently below the applicable water quality standards, further supporting this assumption of critical conditions.

All model kinetic parameters were maintained within the model recommended ranges during the calibration process (**Appendix B**). Calibrated kinetic parameters are in close agreement with those calibrated for other reaches in this watershed (described above). Due to a lack of adequate reach hydraulic (cross-section) data for the sampling period, hydraulic parameters (mean velocities and depths) were also treated as calibration parameters. These parameters were varied from the initial values described above in order to achieve the reaeration rates implied by the data and ultimately replicate measured DO profiles. Finally, diffuse flow input concentrations of nutrients and carbonaceous biochemical oxygen demand, as implied by the synoptic data set, were set as part of the calibration process. Final measured vs. modeled calibration profiles, and simulated reaeration rates, are provided in **Appendix B**.

1.5.1.9 Sensitivity Analysis

A sensitivity analysis was conducted to determine the most sensitive model parameters. The selection of SOD rates and the reaeration model were the most sensitive model parameters included in the analysis. Moderately sensitive parameters included bottom algae growth/respiration/excretion rates and nitrification rates. Geometric properties such as Manning's 'n' were among the least sensitive parameters.

1.5.2 Load Duration Curves

Load duration curves are useful for assessing the range of pollutant loads allowable at various flow rates throughout the full flow regime of a stream. This approach was used to characterize the current loading of fecal coliform bacteria, silver, zinc, TSS, and total phosphorus to HBD-02 of Thorn Creek; fecal coliform to impaired segment HBD-03 of Thorn Creek; fecal coliform, chloride, and total phosphorus to impaired segment HBD-04 of Thorn Creek; fecal coliform and total phosphorus to impaired segment HBD-05 of Thorn Creek; fecal coliform, chloride and total phosphorus to impaired segment HBD-06 of Thorn Creek; fecal coliform to impaired segment HBDB-03 of Butterfield Creek; and fecal coliform and total phosphorus to impaired segments HBDC and HBDC-02 of Deer Creek. Impairments caused by excessive sedimentation or siltation in segments HBDA-01 of North Creek and HBDC-02 of Deer Creek were also assessed using NVSS as a surrogate analyte for the load duration curve methodology. NVSS was selected as a surrogate analyte by Illinois EPA during the development of the agency's LRS methodology.

1.5.2.1 Watershed Delineation and Flow Estimation

Watershed areas for each impaired stream segment were delineated with GIS analyses through use of the National Elevation Dataset, as well as through visual assessment of aerial photographs.

The watershed delineations result in the following estimates of directly contributing watershed used for each impaired segment's load duration curve development:

- Thorn Creek HBD-02: 104 square miles
- Thorn Creek HBD-03: 8.8 square miles
- Thorn Creek HBD-04: 107 square miles
- Thorn Creek HBD-05: 17.8 square miles
- Thorn Creek HBD-06: 25.5 square miles
- North Creek HBDA-01: 22.4 square miles
- Butterfield Creek HBDB-03: 25.8 square miles
- Deer Creek HBDC: 7.8 square miles
- Deer Creek HBDC-02: 26.5 square miles

Figure 1-5 shows the location of the water quality stations on each segment as well as the boundary of the GIS-delineated watersheds.

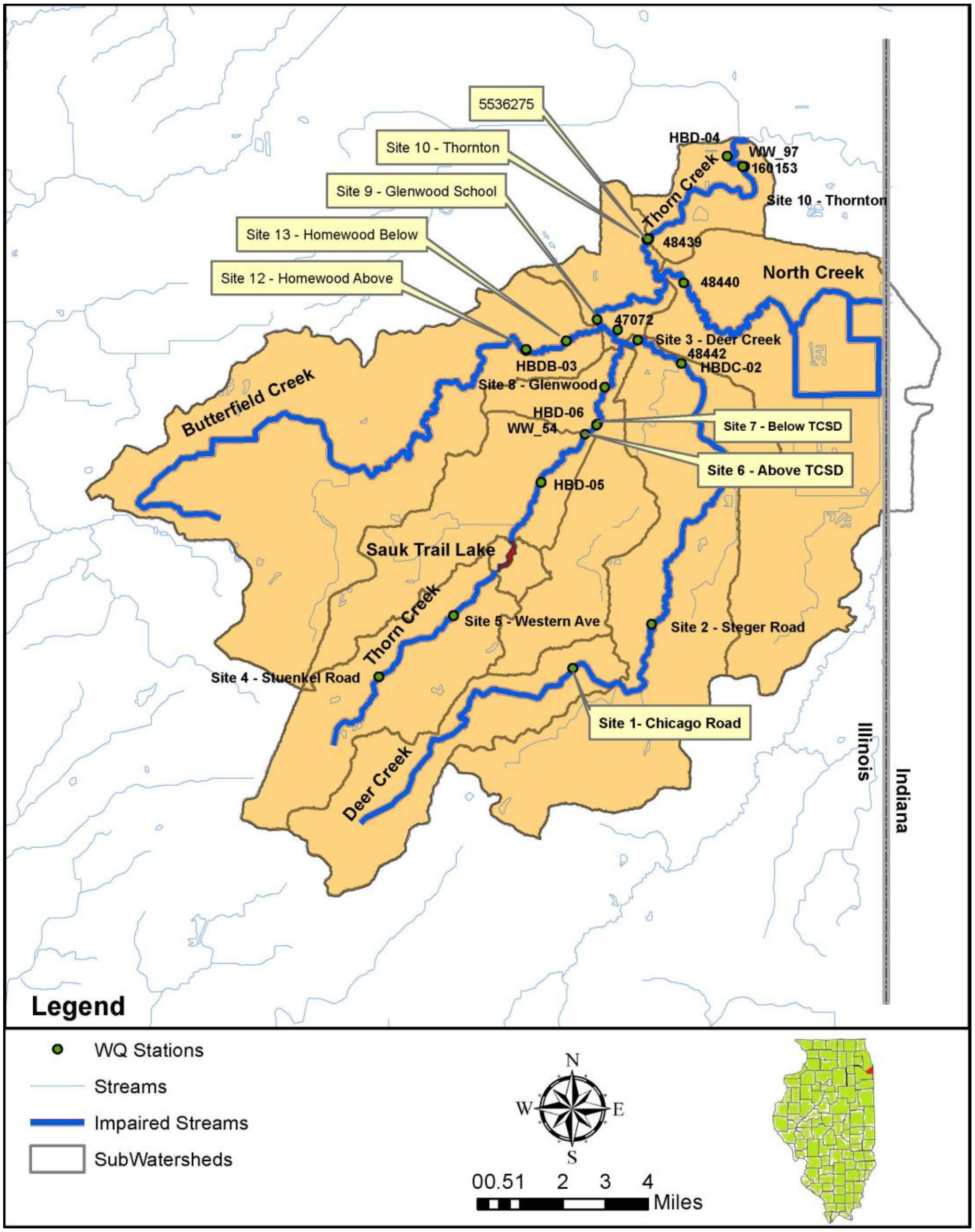


Figure 1-5: Water Quality Sampling Stations in the Thorn Creek Watershed

In order to create a load duration curve, it is necessary to obtain stream flow data that corresponds to each water quality sample. There are five active USGS stream gauges within the Thorn Creek watershed (see **Figure 1-3**). Where available, stream gauges located on an impaired segment were used to estimate flows. In other cases, the closest available gauge with similar watershed characteristics was used to estimate flows using the drainage area ratio method represented by the following equation:

$$Q_{\text{gauged}}\left(\frac{\text{Area}_{\text{ungauged}}}{\text{Area}_{\text{gauged}}}\right) = Q_{\text{ungauged}}$$

where, Q_{gauged} = Streamflow of the gauged basin

$Q_{ungauged}$ = Streamflow of the ungauged basin

$Area_{gauged}$ = Area of the gauged basin

$Area_{ungauged}$ = Area of the ungauged basin

The assumption behind the equation is that the flow per unit area is equivalent in watersheds with similar characteristics. Therefore, the flow per unit area in the gauged watershed multiplied by the ratio of the area of the ungauged watershed to the area of the gauged watershed estimates the flow for the ungauged watershed.

Data downloaded through the USGS for the surrogate gauges for the available periods of record were adjusted to account for point source influences in the watershed upstream of the gauging stations. Average daily flows from all NPDES permitted facilities upstream of the surrogate USGS gauges were subtracted from the gauged flow prior to flow-per unit-area calculations. The resulting estimates account for flows associated with precipitation and overland runoff only. Average daily flows from permitted NPDES discharges upstream of the impaired segments in the Thorn Creek watershed were then added back into the equation to more accurately reflect estimated daily streamflow conditions in a given segment. The gauge used to approximate flow for each impaired stream segment or waterbody are provided in **Table 1-7**. Spreadsheets used for the area ratio flow calculations are provided in **Appendix C**.

Table 1-7: Active USGS Gauges and Applicable Segments/Waterbodies in the Thorn Creek Watershed

Gauge ID	Gauge Name	Gauged Watershed Area (Sq. Miles)	Applicable Impaired Segments
USGS 05536215	Thorn Creek at Glenwood	24.7	Thorn Creek – HBD-03, HBD-05 and HBD-
USGS 05536235	Deer Creek near Chicago Heights	23.1	Deer Creek – HBDC and HBDC-02
USGS 05536255	Butterfield Creek at Flossmoor	23.5	Butterfield Creek – HBDB-03
USGS 05536265	Lansing Ditch near Lansing	8.8	North Creek – HBDA-01
USGS 05536275	Thorn Creek at Thornton	104	Thorn Creek – HBD-02 and HBD-04

1.5.2.2 Fecal Coliform TMDLs for Streams

Flow duration curves for fecal coliform were developed for impaired segments of Thorn Creek (HBD-02, HBD-03, HBD-04, HBD-05, and HBD-06), Butterfield Creek (HBDB-03), and Deer Creek (HBDC and HBDC-02) by determining the percent of days each estimated flow was exceeded, and then graphically plotting the results. However, because the fecal coliform standard is seasonal and is applicable only between the months of May and October, flows not recorded during this time period were omitted from the analyses. The estimated daily stream flows were then multiplied by the more conservative water quality standard of 200 colony forming units (cfu)/100mL (as a daily maximum) to generate load duration curves for each segment. The load duration curves are graphical displays of the maximum allowable load of fecal coliform across all reported flow values for a given stream segment.

To assess primary contact use, Illinois EPA used all fecal coliform bacteria from water samples collected in May through October, for data from 2000 and beyond. Therefore, fecal coliform data collected from each impaired segment between May and October for the most recent years of available data (typically 2000-2014) were compiled from data amassed during Stage 1 of TMDL development. The existing Stage 1 dataset was then supplemented with available additional data collected since the completion of the Stage 1 report. These data were then paired with the corresponding daily average flow for each sampling date and plotted against the load duration curve. The resulting load duration curve figures for each impaired segment depict the maximum allowable load at each flow level along with the observed fecal coliform loads based on sample data (**Figures 1-6** through **1-13**).

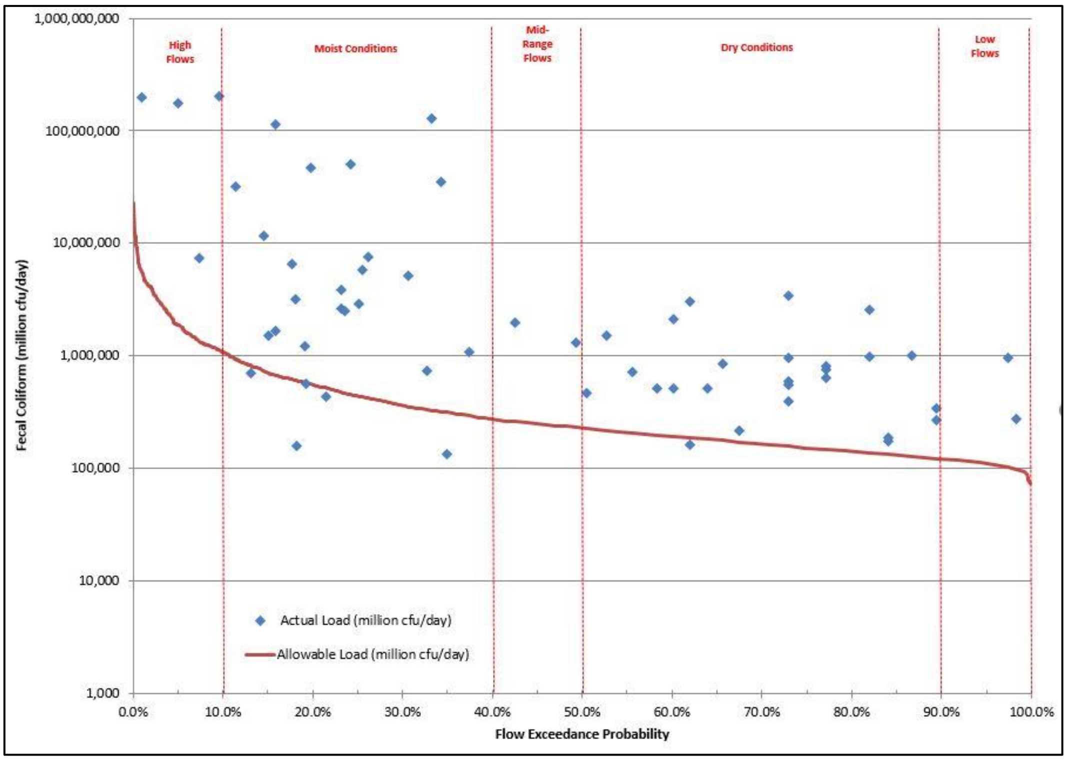


Figure 1-6: Thorn Creek (HBD-02) Fecal coliform Load Duration Curve

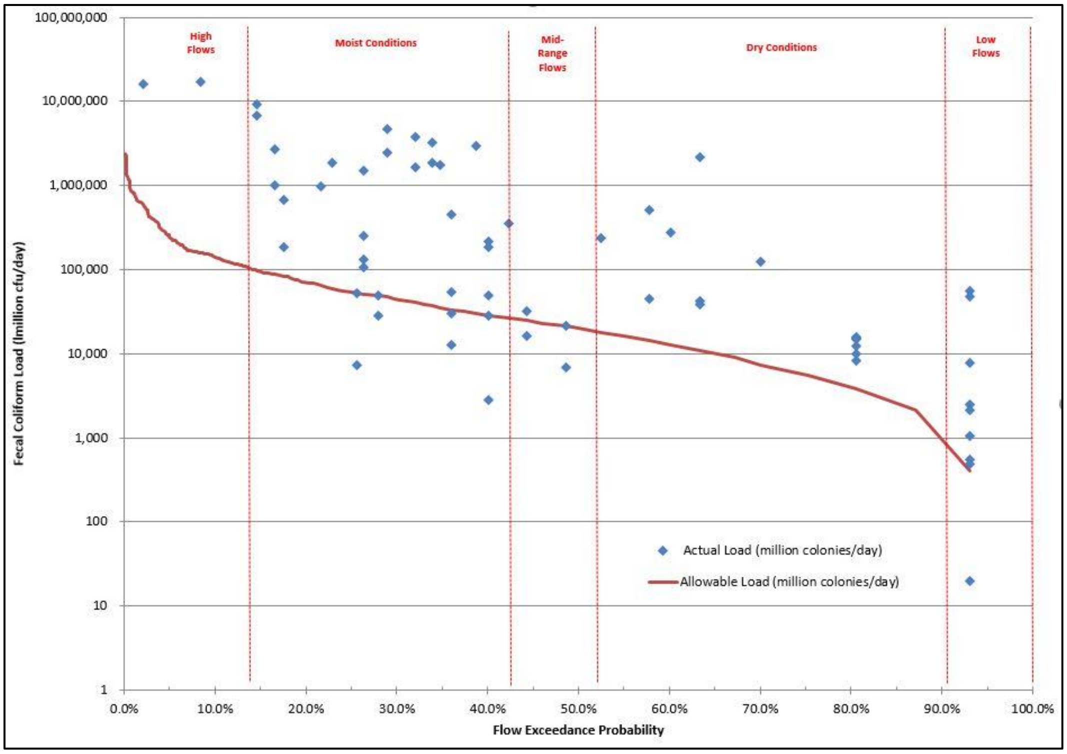


Figure 1-7: Thorn Creek (HBD-03) Fecal coliform Load Duration Curve

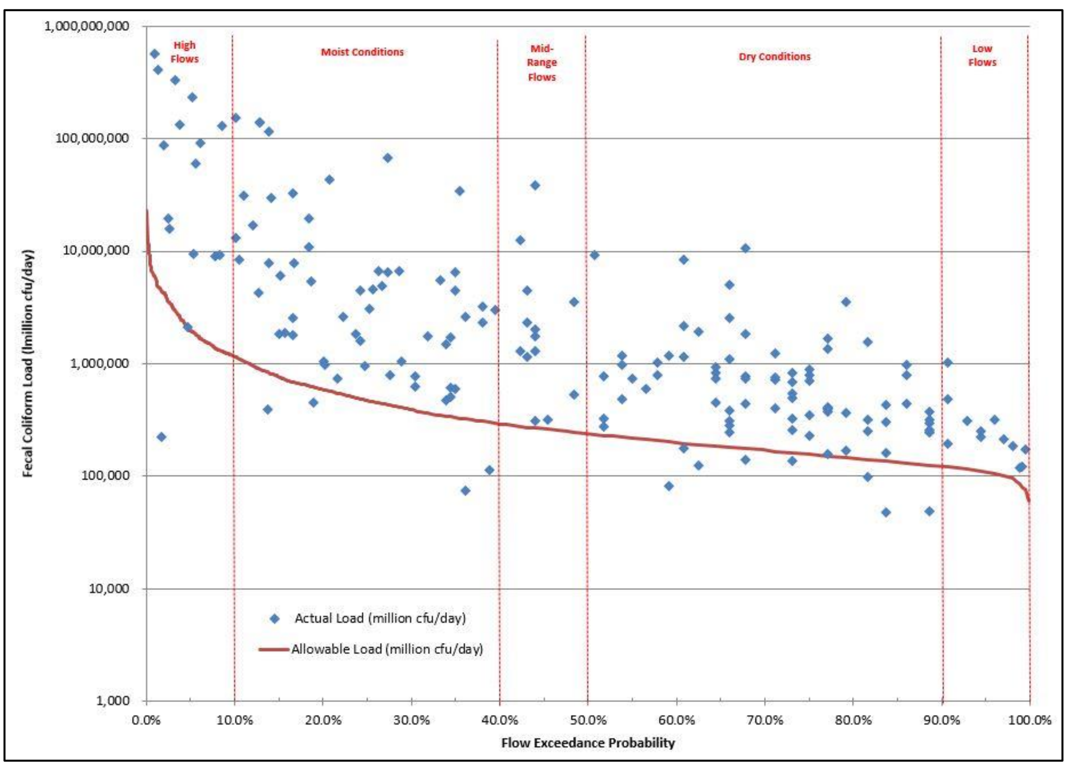


Figure 1-8: Thorn Creek (HBD-04) Fecal coliform Load Duration Curve

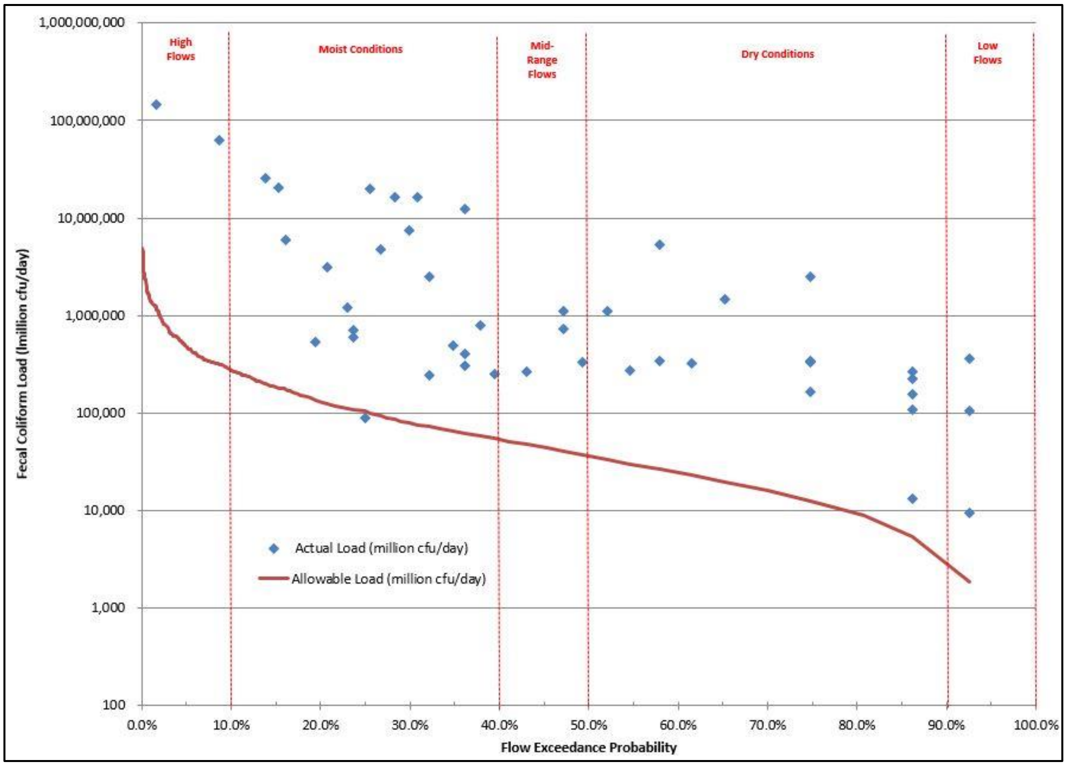


Figure 1-9: Thorn Creek (HBD-05) Fecal coliform Load Duration Curve

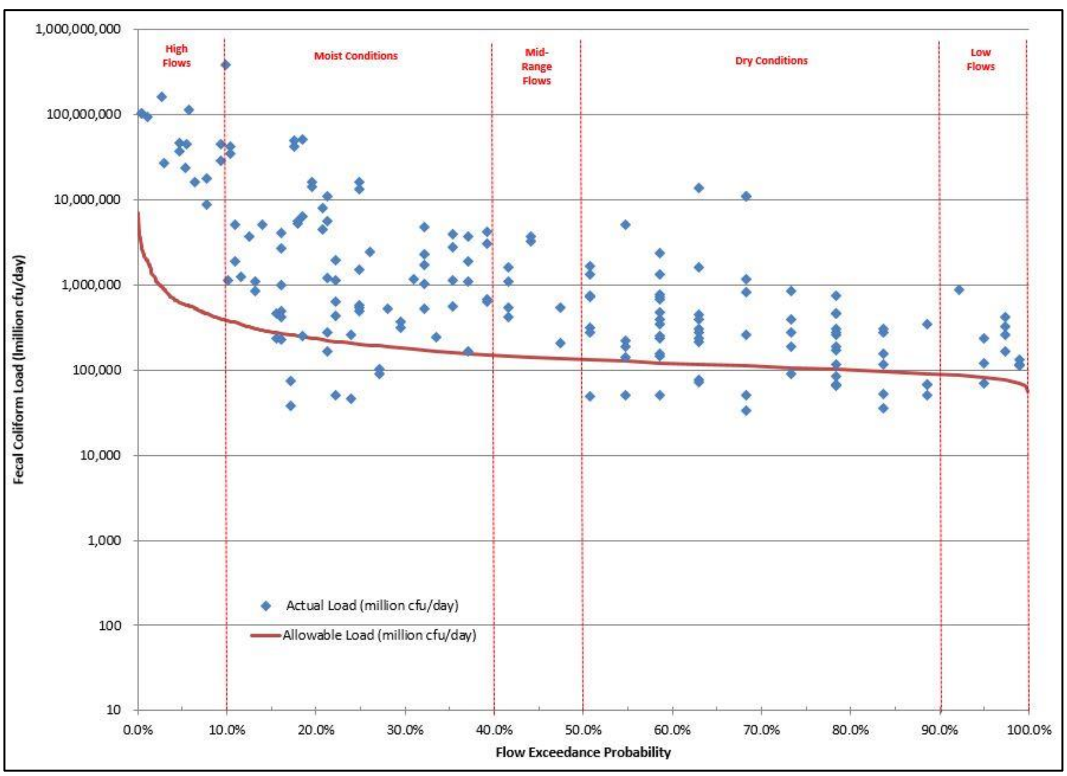


Figure 1-10: Thorn Creek (HBD-06) Fecal coliform Load Duration Curve

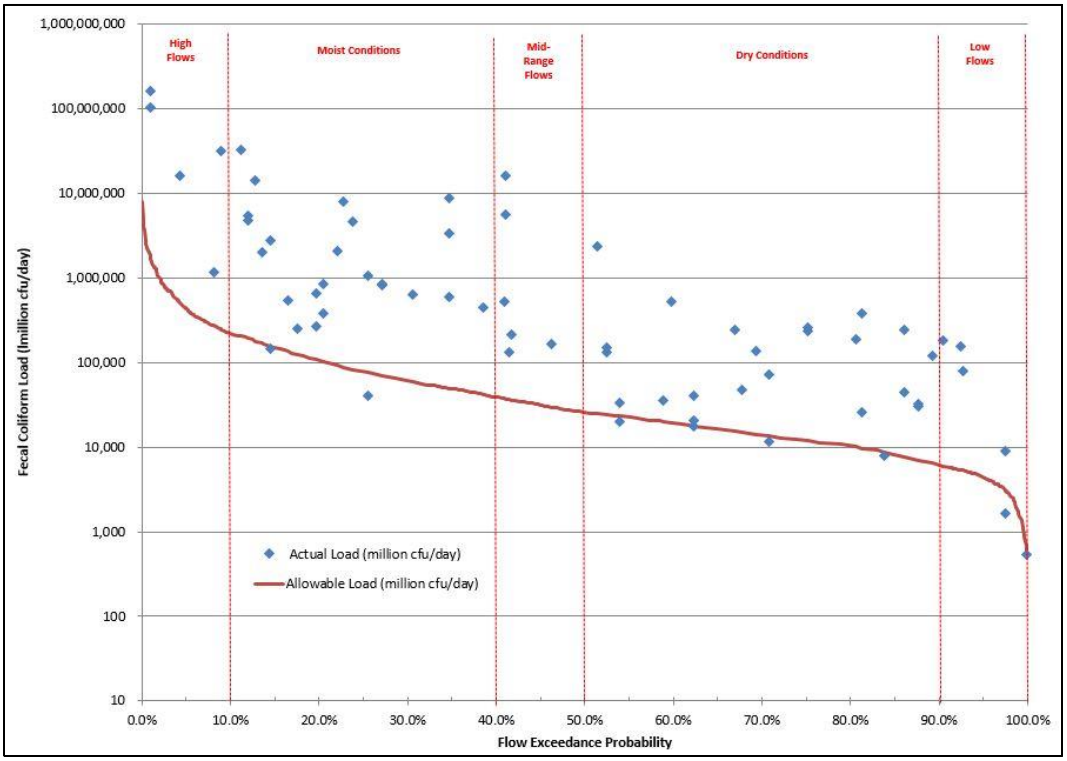


Figure 1-11: Butterfield Creek (HBDB-03) Fecal coliform Load Duration Curve

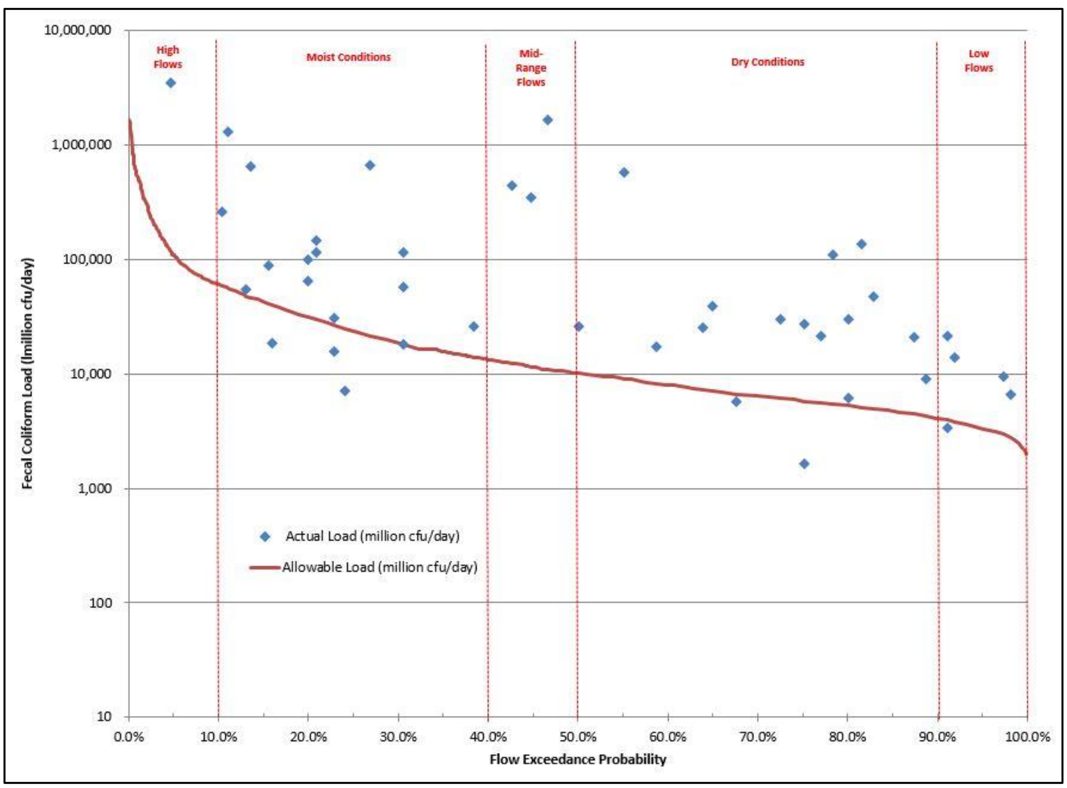


Figure 1-12: Deer Creek (HBDC) Fecal coliform Load Duration Curve

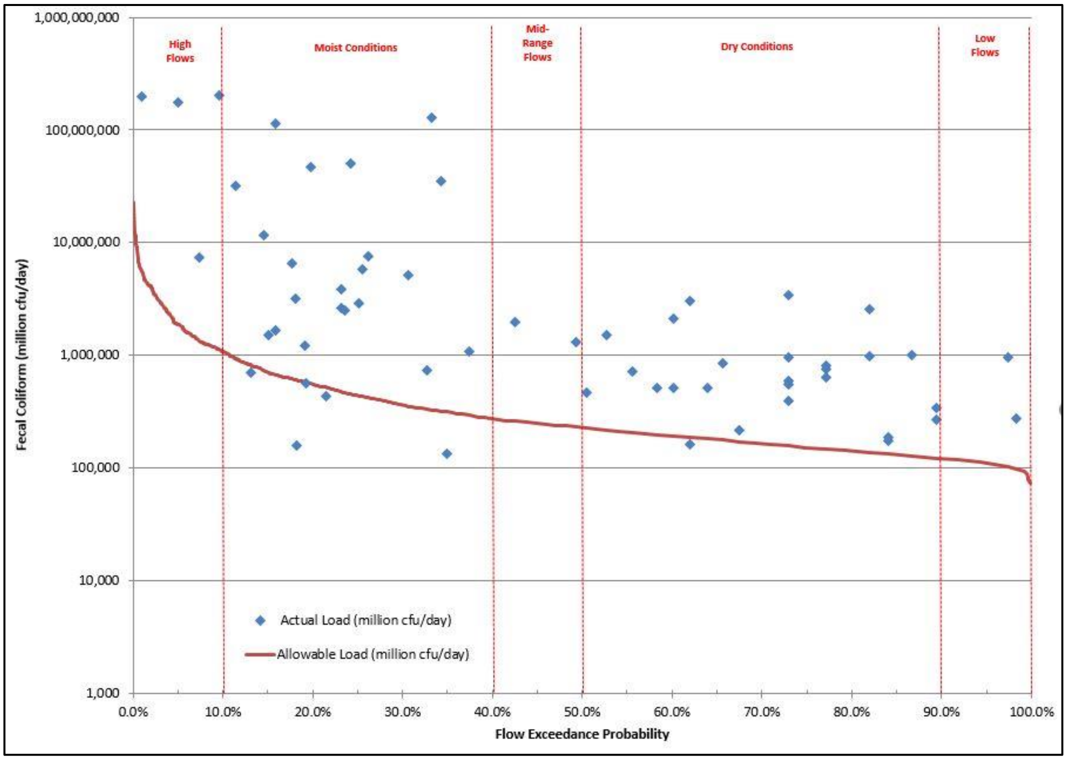


Figure 1-13: Deer Creek (HBDC-02) Fecal coliform Load Duration Curve

The plots of available sample data against the load duration curves show that exceedances of the allowable fecal coliform load consistently occur under all flow conditions in each of the impaired segments. This suggests that the primary sources of fecal coliform loads into impaired segments in the Thorn Creek watershed occur during higher flow conditions, likely in response to overland runoff and urban stormwater resulting from precipitation events, as well as under lower flow conditions, likely in response to point source discharges. **Appendix C** contains the spreadsheets used for the calculations of the load duration curves for fecal coliform in the impaired segments.

1.5.2.3 Chloride TMDLs for Streams

Load duration curves for chloride were also developed to assess TMDLs for the impaired segments (Thorn Creek HBD-04 and HBD-06) using the flow duration curves generated as described above. The flows used in development of the flow duration curve were then multiplied by the applicable water quality standard for chloride (500 mg/L) to generate a load duration curve for chloride for each segment.

Chloride data from 2000 and beyond queried from USEPA STORET, Illinois EPA, MWRD, TCSD and other sources were paired with the corresponding flows for the sampling dates and plotted against the load duration curves. The resulting load duration curve figures developed for each impaired segment depict the maximum allowable chloride load at each flow level along with the actual chloride loads based on observed sample data (**Figures 1-14** and **1-15**).

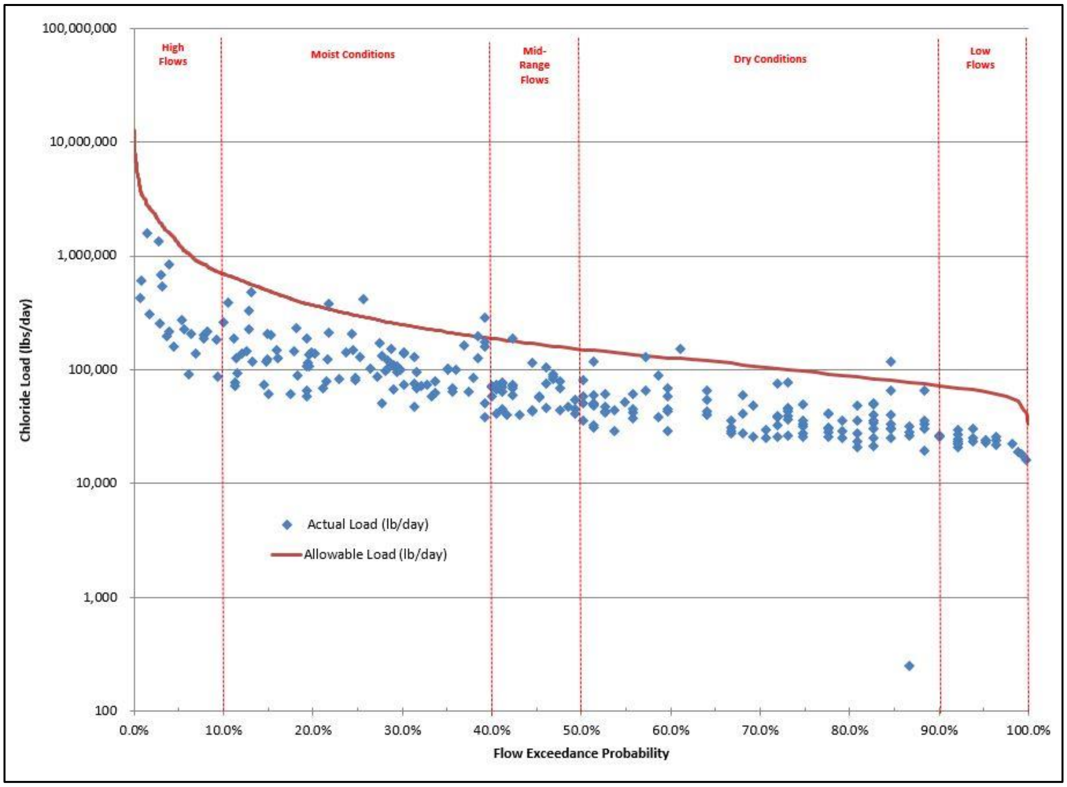


Figure 1-14: Thorn Creek (HBD-04) Chloride Load Duration Curve

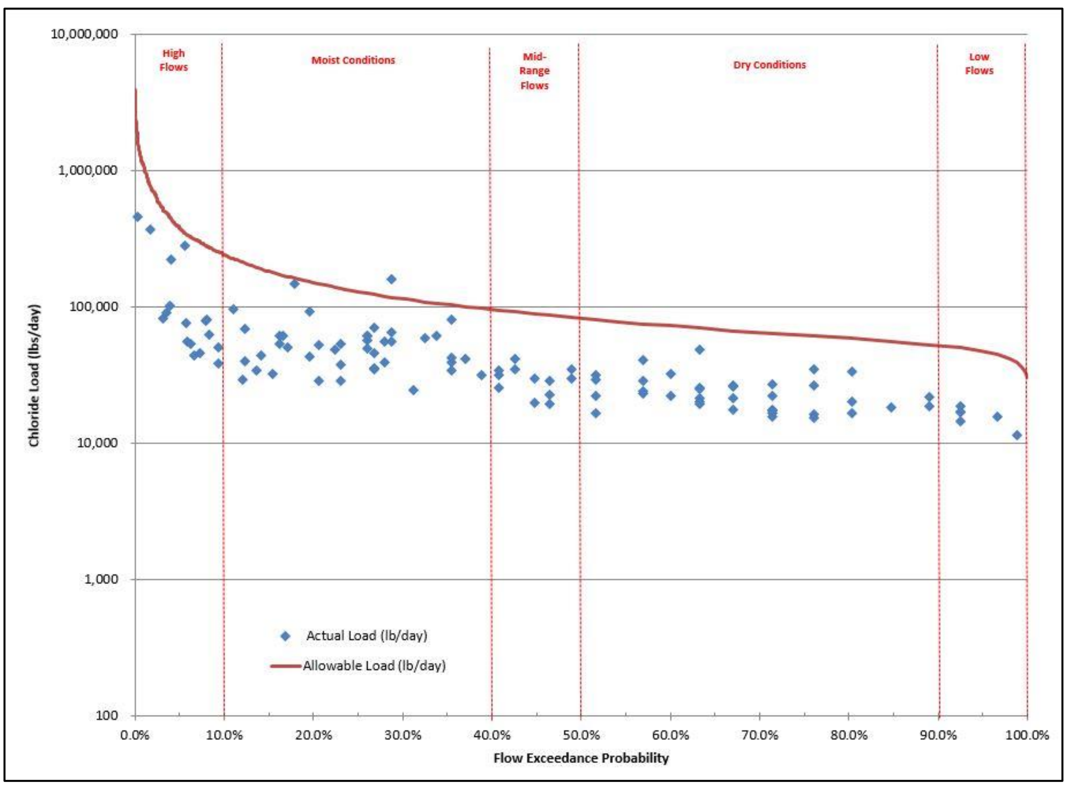


Figure 1-15: Thorn Creek (HBD-06) Chloride Load Duration Curve

Actual loads in excess of the TMDL endpoints occur for only seven of the 274 samples for HBD-04, and for only one of the 113 samples for HBD-06. For HBD-04, excess loads occur under moist, mid-range, and dry flow conditions (but not high or low flow conditions). For HBD-06, the one exceedance occurred under moist conditions. In general, exceedances of the allowable load for chloride did not occur under extremely high or extremely low flows. This trend is consistent with the typical source of chloride loads which is runoff containing road and sidewalk de-icing compounds during winter months. Climate data shows that winter months have less extreme high flow runoff events. Further discussion of the likely sources of chloride loads in the Thorn Creek watershed is provided in **Sections 2** and **3** of this report. Spreadsheets used for the calculation of chloride load duration curves are provided in **Appendix C**.

1.5.2.4 Zinc TMDLs for Streams

A load duration curve for zinc (dissolved) was developed to assess TMDLs for the impaired segment (Thorn Creek HBD-02) using the flow duration curves generated as described above. The flows used in development of the flow duration curve were then multiplied by the applicable water quality standard for dissolved zinc (93 µg/L) to generate a load duration curve for zinc for the impaired segment.

Dissolved zinc data queried from USEPA STORET, Illinois EPA, MWRD, TCSD and other sources were paired with the corresponding flows for the sampling dates and plotted against the load duration curve. The resulting load duration curve figure developed for the impaired segment depicts the maximum allowable zinc load at each flow level along with the actual zinc loads based on observed sample data (**Figure 1-16**).

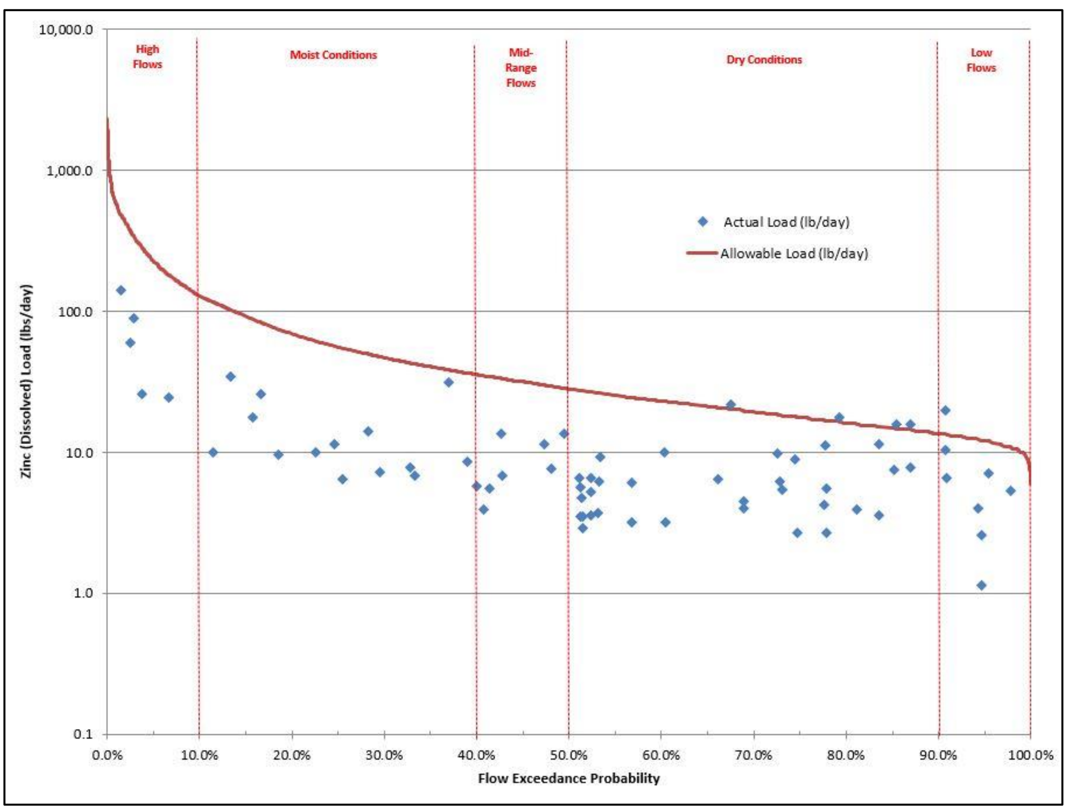


Figure 1-16: Thorn Creek (HBD-02) Zinc Load Duration Curve

The plots of available sample data against the load duration curve show that exceedances of the allowable zinc load occur only under dry and low flow conditions. This suggests that the primary sources of zinc loads into the impaired segment in the Thorn Creek watershed are not runoff related. Further discussion of the likely sources of zinc load in the Thorn Creek watershed is provided in **Sections 2** and **3** of this report. Spreadsheets used for the calculation of zinc load duration curves are provided in **Appendix C**.

1.5.2.5 Silver TMDLs for Streams

A load duration curve for silver (total) was developed to assess TMDLs for the impaired segment (Thorn Creek HBD-02) using the flow duration curve generated as described above. The flows used in development of the flow duration curve were then multiplied by the applicable water quality standard for silver (5.0 µg/L) to generate a load duration curve for silver for the impaired segment.

Silver data queried from USEPA STORET, Illinois EPA, MWRD, TCSD and other sources were paired with the corresponding flows for the sampling dates and plotted against the load duration curve. The resulting load duration curve figure developed for the impaired segment depicts the maximum allowable silver load at each flow level along with the actual silver loads based on observed sample data (**Figures 1-17**). Note that all non-detect results are assigned a zero lbs/day load in this calculation and are not shown on the plot.

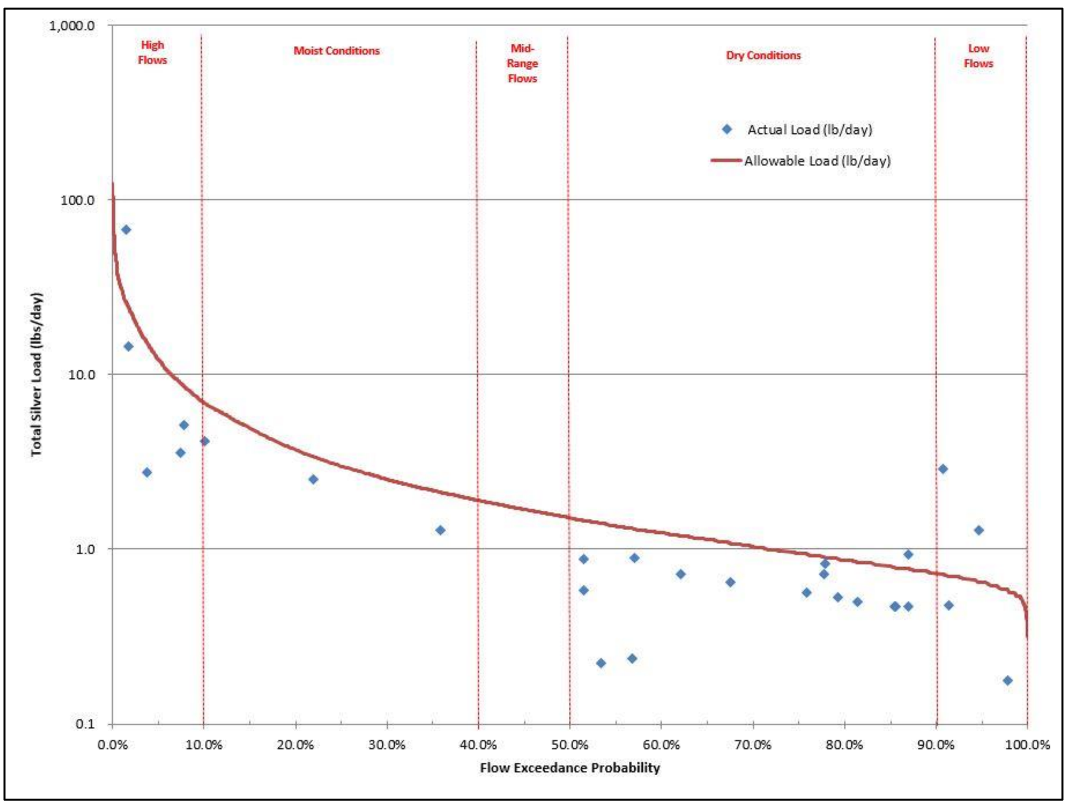


Figure 1-17: Thorn Creek (HBD-02) Silver Load Duration Curve

Actual loads in excess of the TMDL endpoints occur for only four of 272 samples for HBD-02. One exceedance occurred under high flow conditions and three exceedances occur under dry or low flow conditions suggesting that the primary source of silver loads into the impaired segment in the Thorn Creek watershed may be associated with point sources or in response to overland runoff and urban stormwater resulting from precipitation events. However, since only one exceedance was documented at higher flows, it is difficult to attribute the loading definitively to higher flow conditions.

Further discussion of the likely sources of silver load in the Thorn Creek watershed is provided in **Sections 2** and **3** of this report. Spreadsheets used for the calculation of silver load duration curves are provided in **Appendix C**.

1.5.2.6 Total Phosphorus LRSs for Streams

Load duration curves were also developed to calculate the LRSs for total phosphorus in the impaired stream segments HBD-02, HBD-04, HBD-05, HBD-06, and HBDC-02. Segment HBDC is also impaired; however, no water quality data for phosphorus exist for this segment so a load duration curve was not developed. The flows used in development of the flow duration curve were then multiplied by the LRS target (0.226 mg/L) to generate an allowable load duration curve for total phosphorus in each impaired segment.

Total phosphorus data queried from USEPA STORET, Illinois EPA, MWRD, TCSD and other sources were paired with the corresponding flows for the sampling dates and plotted against the load duration curves. The resulting load duration curve figures developed for each impaired segment depict the total phosphorus load that each stream segment can receive at each flow level while remaining below the LRS target, as well as the actual phosphorus loads based on observed sample data (**Figures 1-18** through **1-22**).

Actual phosphorus loads in excess of the allowable target load occur under the full range of flow conditions in each impaired stream segment. In segments HBD-02, HBD-04, and HBD-06, the majority of actual phosphorus loads exceed the allowable load by considerably large margins regardless of the flow condition. In segments HBD-05 and HBDC-02, exceedances of the allowable load remain a common occurrence, but actual loads reported below the allowable load also occur under most flow conditions. While all impaired segments are subject to increased phosphorus loading from overland runoff during mid to high flow conditions, elevated concentrations of phosphorus during low flow conditions are likely the result of point source contributions.

High phosphorus loads seen in many of the impaired segments in the watershed may be associated with point sources in the watersheds upstream of each sampling location. One large municipal treatment facility with potential for discharge of phosphorus loads, the Thorn Creek Basin Sanitary District STP (permit number IL0027723), discharges to segment HBD-06 of Thorn Creek, which flows into segment HBD-02 and then HBD-04 of Thorn Creek. Several additional permitees with phosphorus loads discharge within segment HBD-05 and upstream of segment HBD-06 (permit numbers IL0047562, Park Forest Excess Flow Facility, and IL0035220, Innophos). Neither the Park Forest nor Innophos facility is currently subject to effluent limits for total phosphorus, and only Innophos is required to monitor for this parameter. Discharge

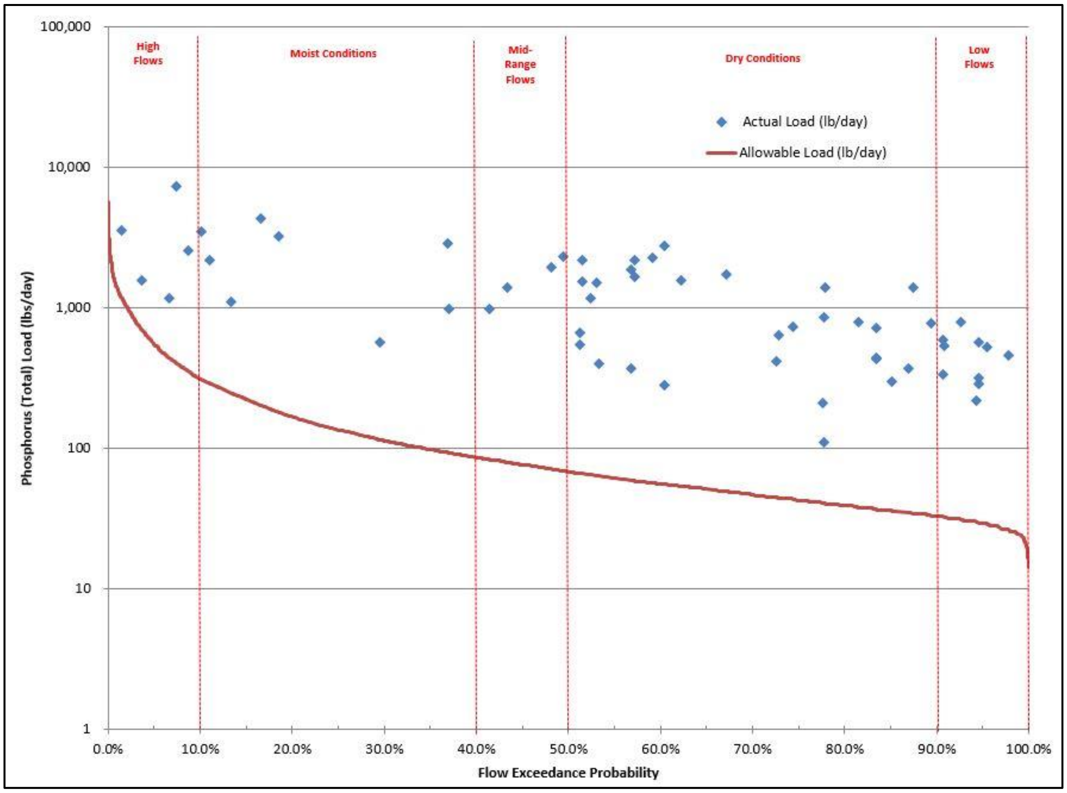


Figure 1-18: Thorn Creek (HBD-02) Phosphorus Load Duration Curve

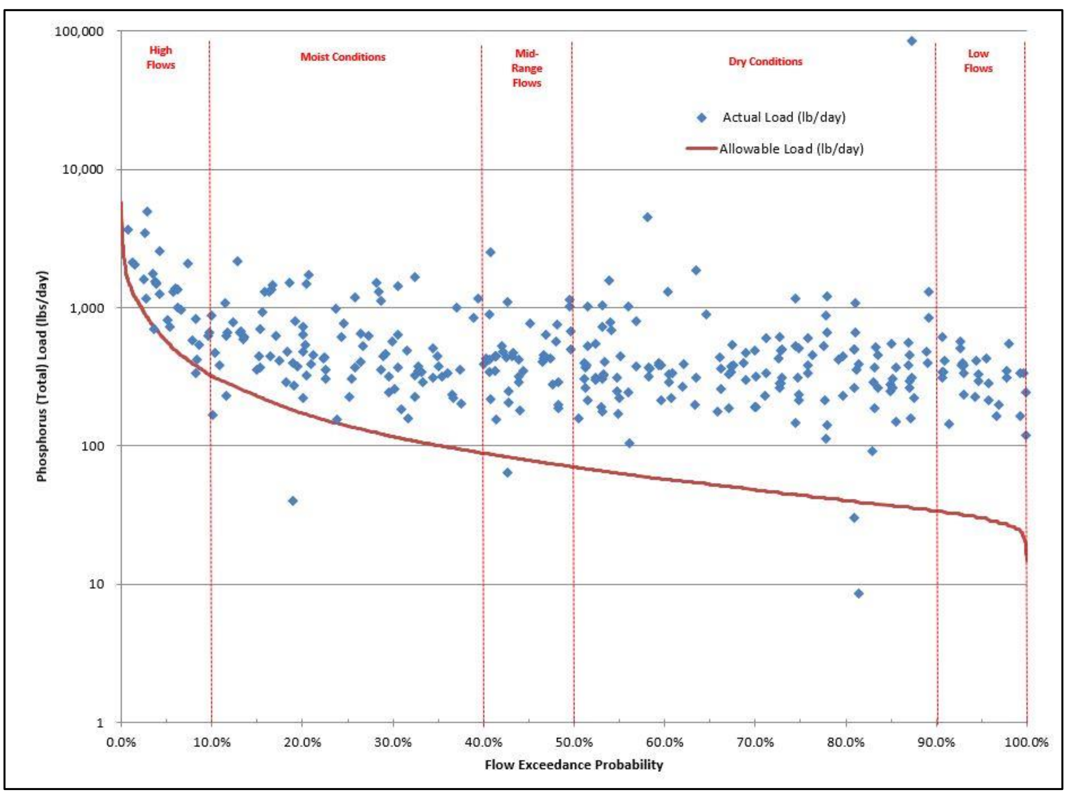


Figure 1-19: Thorn Creek (HBD-04) Phosphorus Load Duration Curve

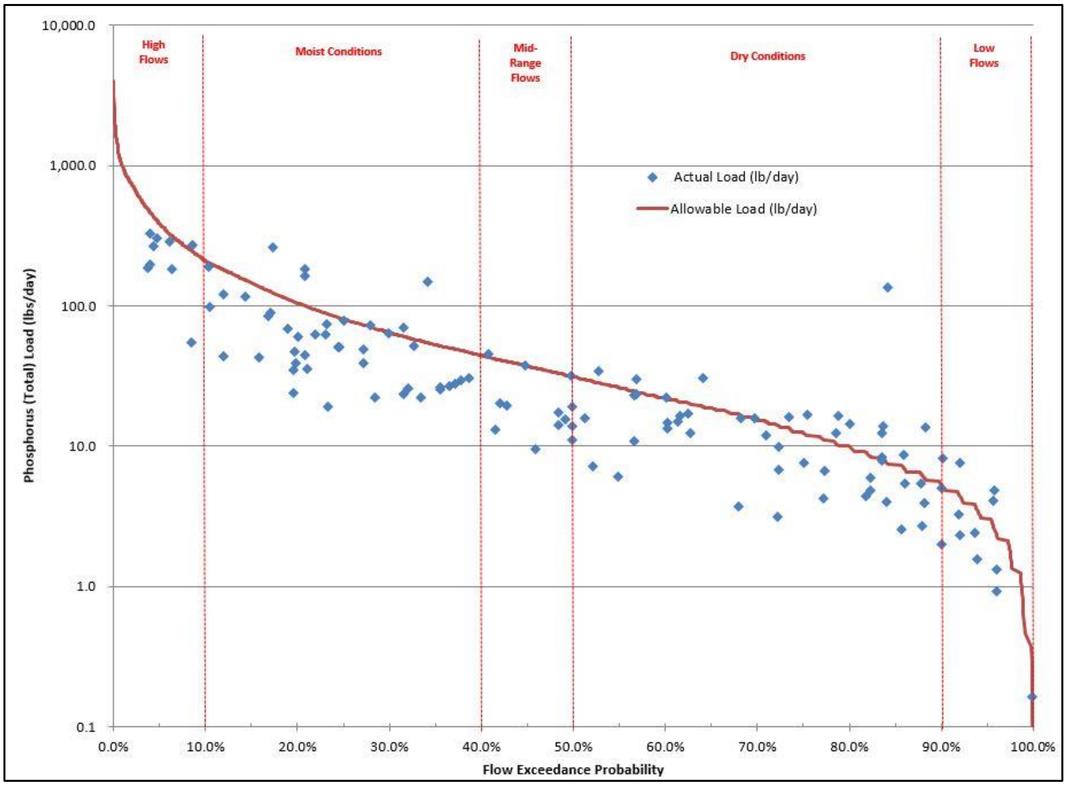


Figure 1-20: Thorn Creek (HBD-05) Phosphorus Load Duration Curve

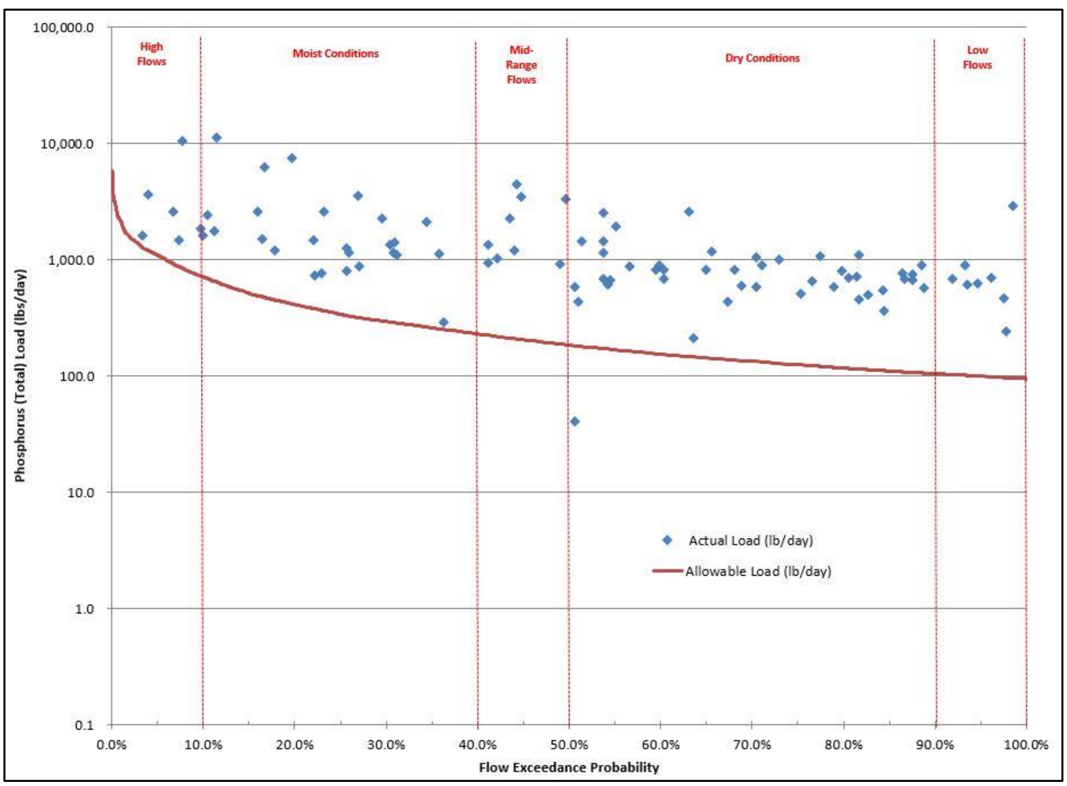


Figure 1-21: Thorn Creek (HBD-06) Phosphorus Load Duration Curve

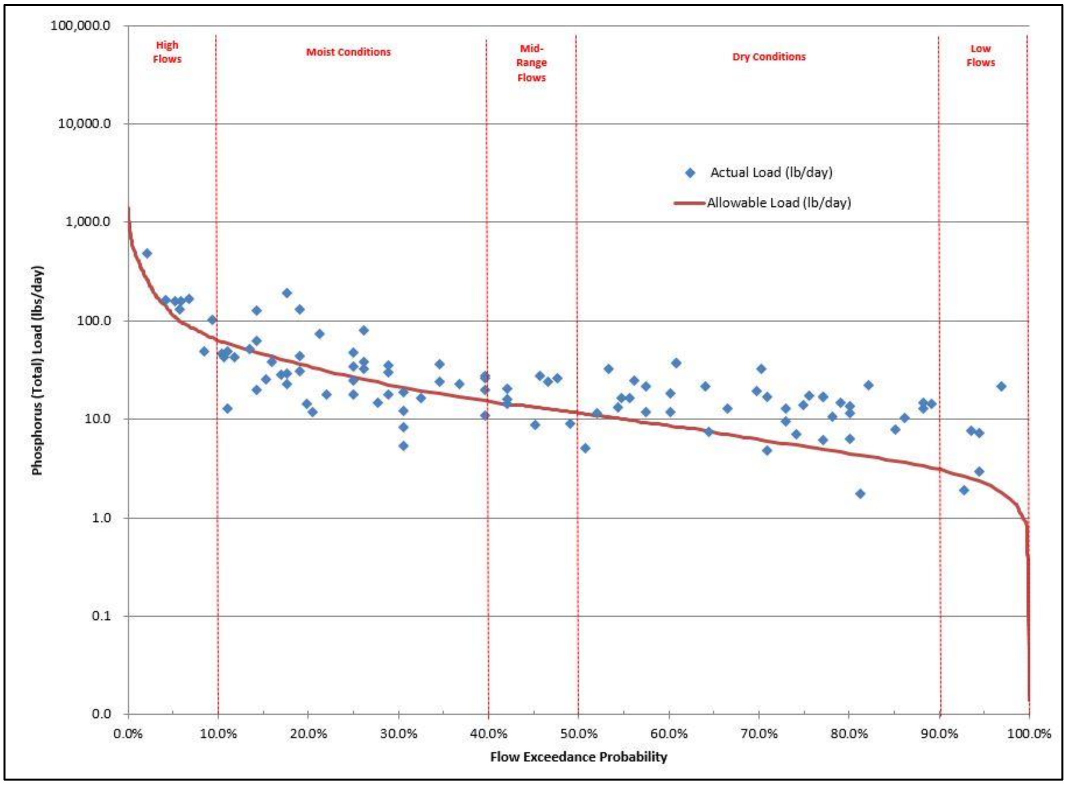


Figure 1-22: Deer Creek (HBDC-02) Phosphorus Load Duration Curve

monitoring reports (DMRs) associated with NPDES permit IL0035220 (Innophos, Inc.) indicate that from October 2015 to August 2016, the facility discharged total phosphorus in concentrations ranging from 9.57 to 116 mg/L with an average monthly concentration of 60.6 mg/L. The four years preceding this, however, there was no discharge from IL0035220. The Park Forest Excess Flow Facility (IL0047562) is not required to monitor for total phosphorus and total phosphorus data were not available for review as of fall 2016. Aqua Illinois – University Park WWTF (permit number IL0024473) discharges upstream of segment HBDC-02 of Deer Creek. This facility has a total phosphorus effluent limit of 1.0 mg/L, as well as loading limits. DMRs associated with NPDES permit IL0024473 indicate that for the last 5 years (September 2011 to August 2016), the facility discharged total phosphorus in concentrations ranging from 0.2 to 3.3 mg/L with an average monthly concentration of 0.85 mg/L.

Further discussion of the sources of total phosphorus loads in the Thorn Creek watershed is provided in **Sections 2** and **3** of this report. Spreadsheets used for the calculation of phosphorus load duration curves are provided in **Appendix C**.

1.5.2.7 TSS and Sedimentation/Siltation LRSs for Streams

A load duration curve was developed for TSS for Thorn Creek segment HBD-02 and for sedimentation/siltation impairments to North Creek segment HBDA-01 and Deer Creek segment HBDC-02. Numeric standards do not exist for TSS or sedimentation and siltation impairments in streams, so the watershed-specific LRS target values provided by Illinois EPA of 72.7 mg/L for TSS and 61.6 mg/L of NVSS were used to develop the load duration curves for these impairments.

NVSS is a surrogate analyte related to TSS (calculated as the difference of TSS minus volatile suspended solids in paired samples) that is currently used by Illinois EPA to develop LRSs for impairments associated with high sedimentation and siltation.

TSS and NVSS data queried from USEPA STORET, Illinois EPA, MWRD, TCSD and other sources were paired with the corresponding flow for the sampling dates and plotted against the load duration curves. The resulting load duration curve figures developed for each impaired segment depict the TSS or NVSS load that each stream segment can receive at each flow level while remaining below the respective LRS targets. The figures also include the actual TSS or NVSS loads under various flow regimes based the available sample data (**Figures 1-23** through **1-25**).

Only eight samples of NVSS exist for segment HBDA-01, with only one exceeding the allowable load, under moist conditions. Only two samples of NVSS exist for segment HBDC-02, with only one exceeding the allowable load, under dry conditions. It is therefore not possible to identify the major driver of sedimentation/siltation impairments in each of these segments. **Appendix C** contains spreadsheets used for the calculation of each of these load duration curves.

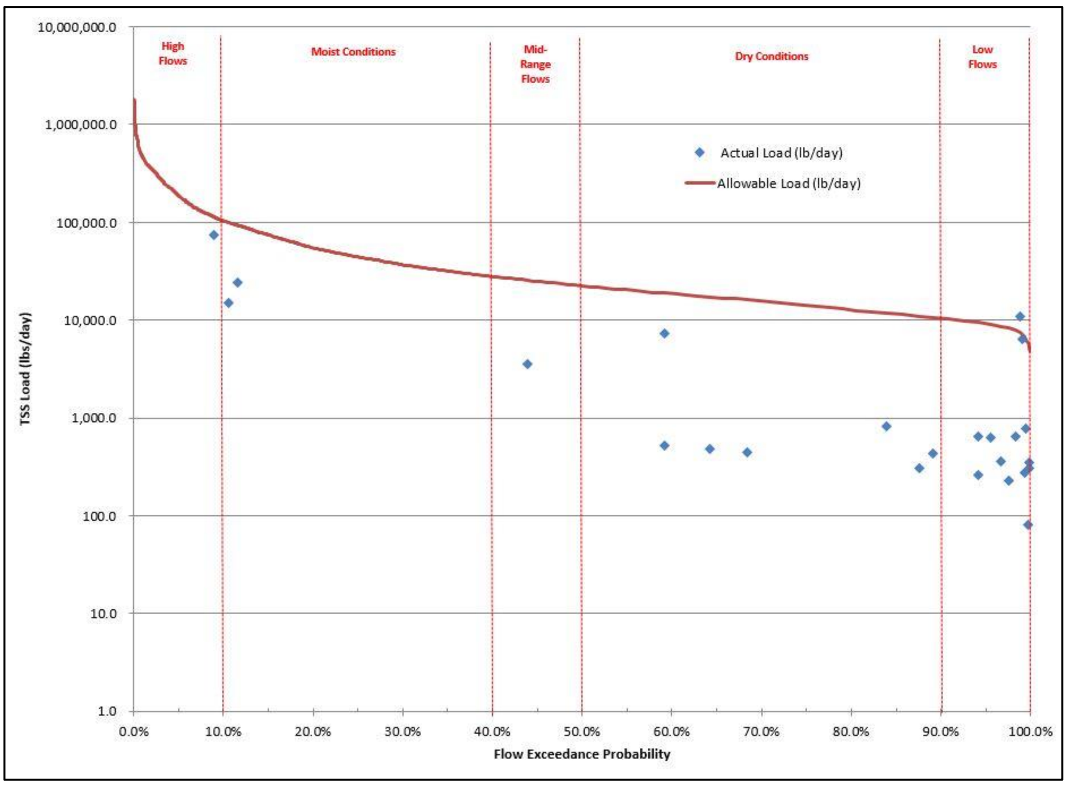


Figure 1-23: Thorn Creek (HBD-02) TSS Load Duration Curve

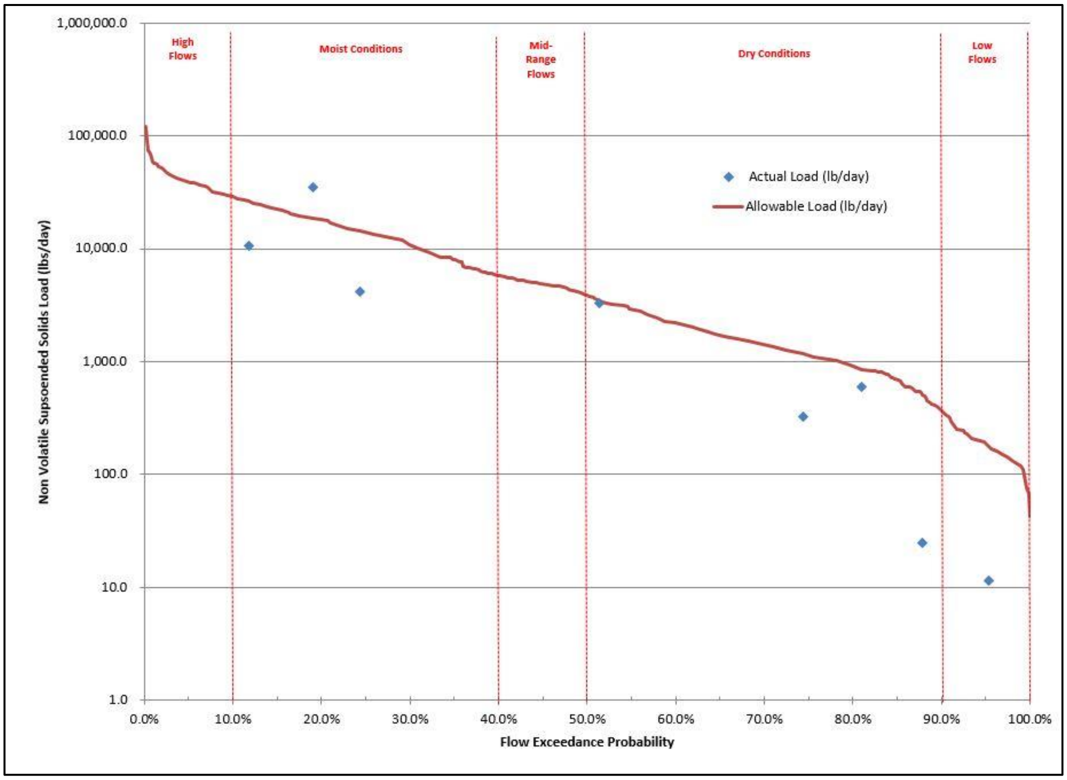


Figure 1-24: North Creek (HBDA-01) NVSS Load Duration Curve

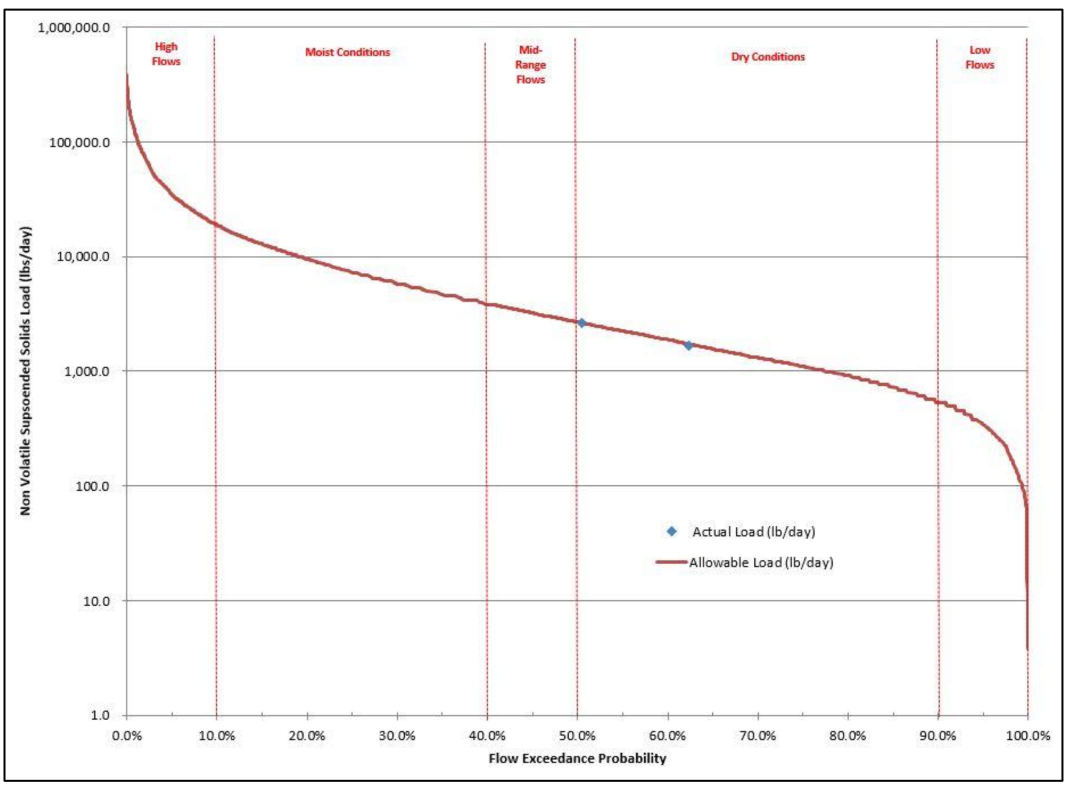


Figure 1-25: Deer Creek (HBDC-02) NVSS Load Duration Curve

1.5.3 BATHTUB Development for Sauk Trail Lake Impairments Caused by Total Phosphorus

Sauk Trail Lake (RHI) is a small, man-made lake along the mainstem of Thorn Creek. It was created in 1923 by damming Thorn Creek, and has a current surface area of 28.8 acres. The lake is primarily used for recreational purposes, and is listed as impaired by total phosphorus. No point sources discharge to this waterbody. The TMDL target for total phosphorus is 0.05 mg/L.

The BATHTUB model was used to develop the total phosphorus TMDL for Sauk Trail Lake. BATHTUB has three primary input interfaces: global, reservoir segment(s), and watershed inputs. The individual inputs for each of these interfaces are described in the following sections along with watershed and operational information for the lake.

TMDL analysis for total phosphorus in Sauk Trail Lake involved the use of observed data coupled with the Rational Method as inputs to the BATHTUB models. This method required inputs from several sources including online databases and GIS-compatible data.

1.5.3.1 Global Inputs

Global inputs represent atmospheric contributions of precipitation, evaporation, and atmospheric phosphorus. The long-term average annual precipitation in the watershed near the Sauk Trail Lake dam is estimated at 38.11 inches based on data from the Park Forest Illinois State Water Survey (ISWS) Weather Station (site 116616) from 1953-2016. The average annual evaporation in the watershed is estimated to be 20.76 inches, based on data from the nearest ISWS pan evaporation station, at the Chicago Botanical Gardens in Glencoe (site 11-1497).

The default atmospheric phosphorus deposition rate suggested in the BATHTUB model was used in absence of site-specific data, which is a value of 30 kilograms per square kilometer (kg/km$^{2)}$-year (U.S. Army Corps of Engineers 1999). This value is based on a compilation of available historical data and Illinois EPA believes that it is appropriate for use in this watershed where site-specific rates of deposition are not available.

1.5.3.2 Reservoir Segment Inputs

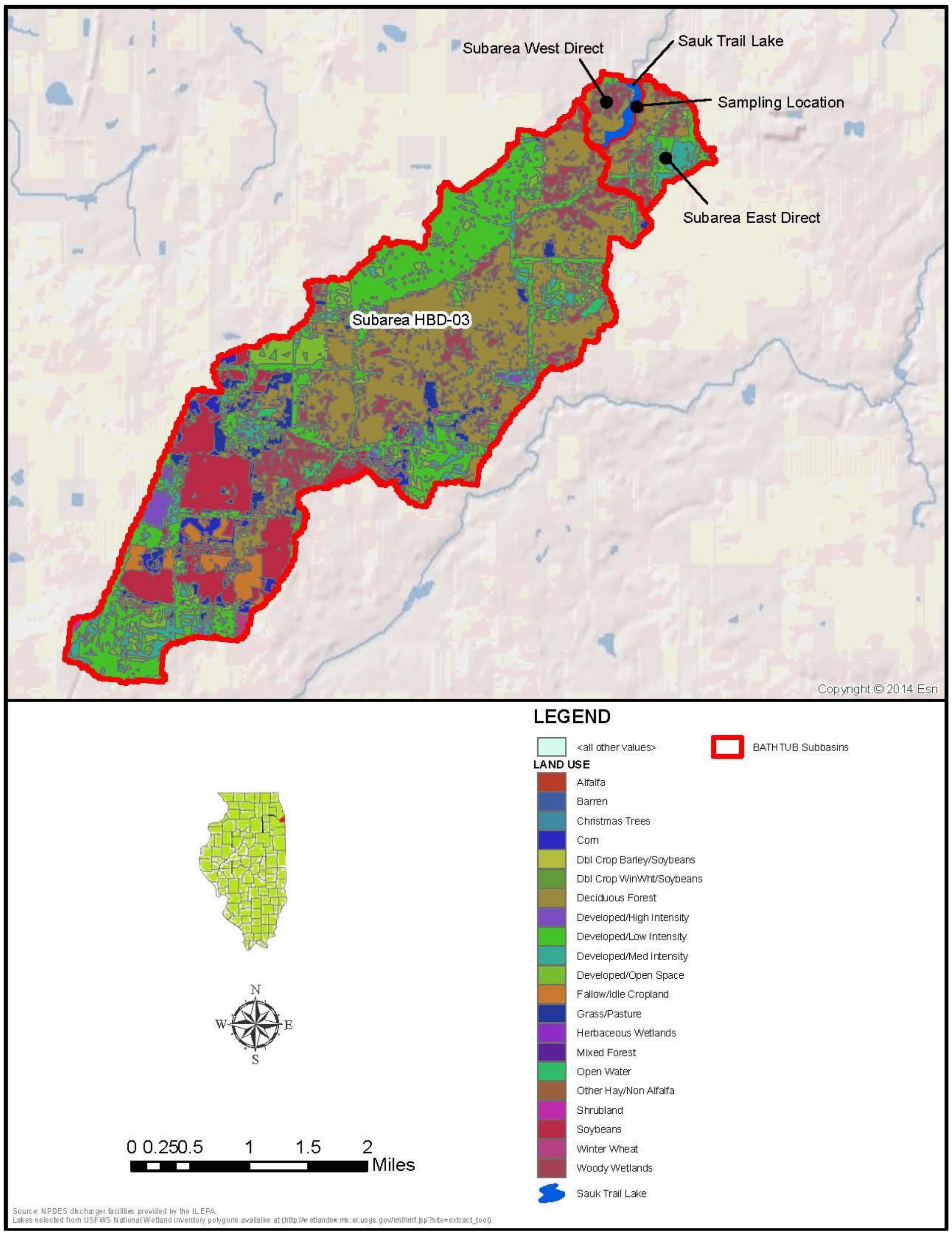
Reservoir segment inputs in BATHTUB are used for physical characterization of the reservoir. Sauk Trail Lake is modeled using one segment in BATHTUB. Segment inputs to the model include average depth, surface area, overall length, and average total phosphorus concentration near the surface of the lake. The lake depth was represented by the average of all depth measurements taken at the one water quality sampling station in the lake. Surface area was determined in GIS. These data are shown below (**Table 1-8**) for reference.

Table 1-8: Sauk Trail Lake Input Data

Segment	Surface Area (km^2)	Segment Length (km)	Average Depth (m)	Average Total Phosphorus at Surface (mg/L)
RHI	0.12	0.8	0.8	0.123

1.5.3.3 Tributary Inputs

Tributary inputs to BATHTUB include drainage area, flow, and total phosphorus loading. The drainage area of each tributary is equivalent to the basin or subbasin it represents, which was determined using GIS analyses. **Figure 1-25** shows the subbasin boundaries. The watershed was broken up into three subbasins for purposes of the model – the upper Thorn Creek tributary to Sauk Trail Lake (HBD-03), one small basin that discharges mainly sheet flow directly to the lake from the west (West Direct), and a small basin that directly discharges to the lake from the east (East Direct).



Note: Land Use data is from the 2015 Cropland Data Layer. Source: USDA.

Figure 1-26: Sauk Trail Lake (RHI) BATHTUB Sub-Basins

The Rational Method was used to estimate the runoff from each subbasin. The runoff coefficient and rainfall intensity used for the calculations were based on land use and the average monthly precipitation for the corresponding months for each season. The average wet and dry season flows for Thorn Creek were estimated using data from the downstream Thorn Creek gauge (USGS 05536215) by removing the TCSD's discharge flow and then scaling by watershed area. The estimated flow from each subbasin is shown in **Table 1-9**.

Table 1-9: Sauk Trail Lake Tributary Inputs and Estimated Flows

Subbasin ID	Tributary Description	Subbasin Area (acres)	Estimated Average Flow Rate (cfs)	Estimated Average Total Phosphorus Concentration (mg/L)
Trib1: Il_RHI	West Direct	144	0.30	0.049
Trib2: Il_RHI – East	East Direct	364	0.76	0.156
Trib3: Il_HBD-03	Flow from Thorn Creek	5,603	11.7	0.142

Because there are limited available historical tributary concentration data, phosphorus loads from the contributing watershed were estimated based on land use data and the median annual export coefficients for each land use. Export coefficients for each land use category found in the Thorn Creek watershed are average values used for TMDLs in Illinois. The export coefficients for each land use are reported in lbs/acre/year, which can then be multiplied by the number of acres of each land use in each of the lake segment's subbasins to provide a total median phosphorus load into the reservoir.

1.5.3.4 BATHTUB Confirmatory Analysis

Historical water quality data for Thorn Creek are summarized in **Section 1.3.1** of this report and were used to help confirm model calculations. Although the analyses presented below do lend confidence to the modeling, they should not be considered a true model "calibration." Additional lake and tributary water quality and flow data are required to fully calibrate the model.

The Sauk Trail Lake BATHTUB model was initially simulated assuming default phosphorus kinetic parameters (assimilation and decay) and a small (5 mg/m^2/day) internal phosphorus loading. When using these parameter settings, the BATHTUB model over-predicted the concentrations when compared to actual water quality data. To achieve a better match with actual water quality data, the internal loading and sedimentation coefficients were iteratively adjusted within reasonable ranges established in the available literature. Internal loading rates reflect nutrient recycling from bottom sediments while sedimentation coefficients reflect variations in sedimentation (settling) rates of individual reservoirs and portions of the reservoir as a function of flows, climate, morphology, and other factors.

As can be seen in **Table 1-10**, an excellent match was achieved, lending significant support to the predictive ability of this simple model. A printout of the BATHTUB model files is provided in **Appendix D** of this report.

Table 1-10: Summary of Model Confirmatory Analysis – Sauk Trail Lake Total Phosphorus

Lake Site	Observed (mg/L)	Predicted (mg/L)	Internal Loading Rate (mg/m^2/day)
RHI1	0.123	0.123	0.5

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Section 2

Total Maximum Daily Loads for the Thorn Creek Watershed

2.1 TMDL Endpoints for the Thorn Creek Watershed

The TMDL endpoints and LRS target values for impairments in the Thorn Creek watershed are summarized in **Table 2-1**. For all parameters except for DO, the concentrations must be less than the TMDL endpoint or LRS target value. The TMDL endpoints for fecal coliform and DO vary seasonally while all other endpoints are consistent throughout the year. All of these endpoints, except for the endpoint established for fecal coliform, are based on protection of aquatic life in the impaired segments in the Thorn Creek watershed. The TMDL endpoint for fecal coliform is based on protection of the primary body contact recreational use. The endpoints for total phosphorus and TSS in lakes are based on protection of the aesthetic quality designated use as well as the protection of aquatic life.

Parameters with numeric water quality standards are assessed via the TMDL process and the TMDL endpoints directly correlate to the lowest applicable water quality standard established for a given parameter. Parameters without numeric water quality standards were assigned a watershed-specific LRS target value by Illinois EPA. The LRS targets are based on data from all stream segments within the HUC-10 basins of the watershed, as well as stream segments or lakes that closely border the watershed in neighboring HUC-10 basins, in order to best represent the land use, hydrologic, and geologic conditions unique to the watershed. Load reduction targets were calculated by Illinois EPA using data from stream segments for which the most current assessment shows full support for aquatic life and data that has passed quality assurance and quality checks within Illinois EPA and are in accordance with state and federal laws. These target values are not legally binding, but are intended to serve as planning tools for overall water quality improvement strategies in the watershed.

Table 2-1: TMDL and LRS Endpoints for Impaired Constituents in the Thorn Creek Watershed

Segment Name/ID	Potential Cause of Impairment	Assessment Type	TMDL Endpoint or Target Value
Thorn Creek (HBD-02)	**Dissolved Oxygen**[1]	TMDL	6.0 mg/L weekly avg. minimum (March -July) 3.5 mg/L minimum (August-February)
	Silver	TMDL	5.0 µg/L
	Zinc	TMDL	355 µg/L (acute)* 93 µg/L (chronic)*
	Fecal Coliform	TMDL	200[(1)] cfu/100ml (May – October)
	Total Phosphorous	*LRS*	*0.226 mg/L*
	TSS	*LRS*	*72.7 mg/L*

Segment Name/ID	Potential Cause of Impairment	Assessment Type	TMDL Endpoint or Target Value
Thorn Creek (HBD-03)	**Dissolved Oxygen**	TMDL	6.0 mg/L weekly avg. minimum (March -July) 3.5 mg/L minimum (August-February)
	Fecal Coliform	TMDL	200(1) cfu/100ml (May – October)
Thorn Creek (HBD-04)	**Dissolved Oxygen**	TMDL	6.0 mg/L weekly avg. minimum (March -July) 3.5 mg/L minimum (August-February)
	Fecal Coliform	TMDL	200(1) cfu/100ml (May – October)
	Chloride	TMDL	500 mg/L
	Total Phosphorus	*LRS*	*0.226 mg/L*
Thorn Creek (HBD-05)	**Fecal Coliform**	TMDL	200(1) cfu/100ml (May – October)
	Total Phosphorus	*LRS*	*0.226 mg/L*
Thorn Creek (HBD-06)	**Dissolved Oxygen**	TMDL	6.0 mg/L weekly avg. minimum (March -July) 3.5 mg/L minimum (August-February)
	Fecal Coliform	TMDL	200(1) cfu/100ml (May – October)
	Chloride	No TMDL Developed	No longer impaired – recommended for delisting
	Total Phosphorus	*LRS*	*0.226 mg/L*
North Creek (HBDA-01)	**Dissolved Oxygen**	TMDL	6.0 mg/L weekly avg. minimum (March -July) 3.5 mg/L minimum (August-February)
	Sedimentation/Siltation	*LRS*	*61.6 mg/L of NVSS*
Butterfield Creek (HBDB-03)	**Fecal Coliform**	TMDL	200(1) cfu/100ml (May – October)
Deer Creek (HBDC)	**Fecal Coliform**	TMDL	200(1) cfu/100ml (May – October)
	Total Phosphorus	*LRS*	*0.226 mg/L*
Deer Creek (HBDC-02)	**Dissolved Oxygen**	TMDL	6.0 mg/L weekly avg. minimum (March -July) 3.5 mg/L minimum (August-February)
	Fecal Coliform	TMDL	200(1) cfu/100ml (May – October)
	Total Phosphorus	*LRS*	*0.226 mg/L*
	Sedimentation/Siltation	*LRS*	*61.6 mg/L of NVSS*
Sauk Trail Lake (RHI)	**Dissolved Oxygen**	TMDL for Total Phosphorus	0.05 mg/L TP
	Total Phosphorus	TMDL	
	Sedimentation/Siltation	*LRS*	*61.6 mg/L of NVSS*
	TSS	*LRS*	*72.7 mg/L*

(1) Geometric mean based on a minimum of five samples taken over not more than a 30-day period.

* Zinc acute and chronic standards were calculated based on water hardness, per the formulas codified in the Illinois Water Quality Standards, Section 302.208(e). An average water hardness was determined based on all hardness water quality samples available. Average hardness was 362 mg/L. Calculations for average hardness and acute and chronic zinc standards are included in **Appendix E**.

2.2 Pollutant Sources and Linkages

Potential pollutant sources for impaired lakes and streams in the Thorn Creek watershed include both point and nonpoint sources. Pollutants impairing the Thorn Creek watershed include fecal coliform, chloride, zinc, silver, dissolved oxygen, and total phosphorus.

Sources of Fecal Coliform

Point sources of fecal coliform consist of two large POTWs (Thorn Creek Sanitary District STP and Aqua Illinois – University Park WWTF), two excess-flow POTWs (Homewood Excess Flow Treatment Plant and Park Forest Excess Flow Facility) and two small mobile home park treatment plants (Ely's Mobile Home Park STP and Paradise Park MHP STP). The facilities are located both on tributaries of the impaired segments and, in some cases, directly discharge effluent to the impaired stream segments.

Likely nonpoint sources of fecal coliform in the watershed include wildlife waste, domestic pet waste, and overland stormwater runoff. Other nonpoint sources for fecal coliform can include septic systems. While the entirety of the watershed is currently within the service area of a municipal sewer system, functional or abandoned septic systems potentially still exist within the watershed, the existence and prevalence of which is not known.

Sources of Chloride

There are twelve NPDES permitted point sources present within the Thorn Creek watershed, and these facilities are located both on tributaries of the impaired segments and, in some cases, they directly discharge effluent to the impaired stream segments. Only two of the listed facilities, Aqua Illinois – University Park WWTF and Park Forest WTP have discharge monitoring requirements for chloride.

Land use around the Thorn Creek watershed is approximately 58% urban overall, with denser urban areas towards the downstream end of the watershed. Nonpoint chloride sources may therefore originate from road de-icing activities using chloride salts.

Sources of Silver and Zinc

Point sources of zinc within the Thorn Creek watershed tributary to segment HDB-02 include Aqua Illinois – University Park WWTF. There are no identified point sources that have permit limits or monitoring requirements for silver.

Nonpoint sources of zinc include aging galvanized iron and steel, road salt, and tire wear (Schueler and Shepp 1993). Runoff from undeveloped, park, and agricultural lands are potential nonpoint sources of zinc and silver pollution to the impacted stream segment, since both metals can be carried on sediments.

Sources of Phosphorus and Oxygen Demanding Materials

Point sources discharging to impaired streams within the Thorn Creek watershed include municipal sewage treatment facilities and industrial dischargers. **Table 1-6** contains permit information on the treatment facilities, as well as model input parameters used in the QUAL2K modeling discussed in **Section 2** of this report. As discussed in **Section 1.5.2.6**, two large municipal treatment facilities discharge to, or upstream of, segments HBD-02, HBD-04, HBD-06, HBCD, and/or HBDC-02. Only one facility is currently subject to effluent limits for total phosphorus, and the other is only required to monitor for this parameter. The two existing POTW facilities also discharge oxygen-demanding materials, as measured by BOD. There are also numerous smaller dischargers that discharge phosphorus to the streams in the watershed. The facilities discharge to tributaries of the impaired segments, or in some cases, directly to the impaired stream segments.

Potential stormwater-related inputs of nutrients to the impacted streams in the watershed include MS4 and non-MS4 urban runoff, and runoff from agricultural, undeveloped, and park lands. In addition, inputs are often caused by nutrient applications in urban settings, such as fertilizer inputs on lawns, golf courses, and other intensively used and maintained landscapes. Nutrients adsorb to soils and enters waterways with runoff and erosion, resulting in excessive growth of algae and other aquatic plants, which impairs aesthetics, water quality, and recreational potential.

Load duration curves were developed for fecal coliform, chloride, silver, and zinc TMDLs, as well as for the total phosphorus, TSS, and sedimentation/siltation LRSs in stream segments. Load duration curves are useful in that they provide a link between historical sampling values and hydraulic condition. **Table 2-2** shows the example source area/hydrologic condition considerations developed by USEPA. Pollutant sources for TSS in lakes are likely similar to those identified for stream segments impaired by these parameters.

Table 2-2: Example Source Area/Hydrologic Condition Considerations (USEPA 2007)

	Duration Curve Zone				
Contributing Source Area	**High Flow**	**Moist**	**Mid-Range**	**Dry**	**Low Flow**
Point Source				M	H
Onsite Wastewater System			H	M	
Riparian Areas		H	H	H	
Stormwater: Impervious Areas		H	H	H	
Combined sewer overflows	H	H	H		
Stormwater: Upland	H	H	M		
Bank Erosion	H	M			

Note: potential relative importance of source area to contribute loads under given hydrologic conditions (H: High, M: Medium)

Other pollutant sources and their linkages to Sauk Trail Lake were established through the modeling (BATHTUB) as discussed in **Section 1**. Modeling indicated that loads of total phosphorus may originate from internal and external sources. Overall potential sources of nutrients in the impaired lake watersheds include point and nonpoint sources such as runoff from surrounding developed areas, forest and parkland, waterfowl, and internal loading from lake sediments. Nutrients bound in eroded soils and plant materials are introduced to the waterbodies through runoff from precipitation events. Once in the waterbodies, nutrients are introduced to the water column and/or nutrient rich soils and plant materials settle to the bottom perpetuating the internal cycling of nutrients.

Pollutant sources and linkages for stream segments impaired by low DO (Thorn Creek HBD-02, Thorn Creek HBD-03, Thorn Creek HBD-04, Thorn Creek HBD-06, North Creek HBDA-01, and Deer Creek HBDC-02) were established through the QUAL2K modeling effort. Modeling indicated that low DO levels in this watershed are driven primarily by a combination of low reaeration and high SOD. Further pollutant source discussion is provided throughout this section and implementation activities to reduce loading from the potential sources are outlined in **Section 3**.

2.3 TMDL Allocation

The TMDLs for impaired segments in the Thorn Creek watershed address the following equation:

$$\mathbf{TMDL = LC = \Sigma WLA + \Sigma LA + MOS + RC}$$

where:	LC	=	Loading capacity the maximum amount of pollutant loading a water body can receive without violating water quality standards
	WLA	=	Waste load allocation the portion of the TMDL allocated to existing or future point sources
	LA	=	Load allocation – the portion of the TMDL allocated to existing or future nonpoint sources and natural background
	MOS	=	Margin of safety an accounting of uncertainty about the relationship between pollutant loads and receiving water quality
	RC	=	Reserve capacity – the portion of the load explicitly set aside for future population growth and additional development in the watershed

Each of these elements are discussed in this section, as well as consideration of seasonal variation in the TMDL calculation.

2.3.1 Fecal Coliform TMDL

Thorn Creek segments HBD-02, HBD-03, HBD-04, HBD-05, and HBD-06; Butterfield Creek segment HBDB-03; and Deer Creek segments HBDC and HBDC-02 in the Thorn Creek watershed are listed for impairment of the general use standard caused by fecal coliform. Load duration curves were developed (see **Section 1**) to determine load reductions needed to meet the instream water quality standards under varying flow scenarios for each segment.

2.3.1.1 Loading Capacity

The LC is the maximum amount of fecal coliform that Thorn Creek segments HBD-02, HBD-03, HBD-04, HBD-05, and HBD-06; Butterfield Creek segment HBDB-03; and Deer Creek segments HBDC and HBDC-02 can receive and still maintain compliance with the water quality standards. The allowable fecal coliform loads that can be generated in the watershed and still maintain the geometric mean standard of 200 cfu/100mL were determined with the methodology discussed in **Section 1**. The fecal coliform LC according to flow is presented in **Table 2-3**.

2.3.1.2 Seasonal Variation

Consideration of seasonality is inherent in the load duration analysis. Because the load duration analysis represents the range of expected stream flows, the TMDL has been calculated to meet the standard during all flow conditions. In addition, seasonality is addressed because the TMDL has been calculated to address loading only when the seasonal standard is applicable (May through October). The fecal coliform standard must be met under all flow scenarios within the recreation season.

Table 2-3: Estimated Fecal Coliform Loading Capacities Under Various Flow Conditions for Streams in the Thorn Creek Watershed

Estimated Mean Daily Flow (cubic feet per second [cfs])	Load Capacity (mil col/day)
5	24,446
10	48,931
50	244,657
100	489,314
500	2,446,572
1,000	4,893,143
5,000	24,465,715
10,000	48,931,430
15,000	73,397,146

2.3.1.3 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. The MOS incorporated into the fecal coliform TMDL analyses are implicit, as the analyses used the more conservative 200 cfu/100mL standard and did not consider die-off of bacteria, which is likely occurring in the system but unquantified.

2.3.1.4 Waste Load Allocation

WLAs for fecal coliform TMDLs are applied to individually permitted facilities and municipal separate storm sewer discharges (MS4s) that exist in the Thorn Creek watershed, as described below.

Individual NPDES permitted facilities

There are five major individual NPDES permitted dischargers within the Thorn Creek watershed. Four of the major dischargers are municipal publicly owned treatment works (POTWs) (Thorn Creek Basin Sanitary District STP, Aqua Illinois – University Park WWTF, Homewood Excess Flow Treatment Plant and Park Forest Excess Flow Facility) and one is an industrial discharger (Chicago Heights Steel). There are also a number of minor individual NPDES permitted dischargers, including two mobile home park (MHP) treatment plants (Ely's Mobile Home Park STP and Paradise Park MHP) and several other dischargers (Hanson Material Service Yard 41, Mid-West Manufacturing LLC, Innophos Inc., Park Forest WTP and Village of Lynwood CCDD). Details on each NPDES permit and the directly impacted segments are provided in **Table 2-4**. The four POTWs and two MHPs currently have permit limits for fecal coliform bacteria of 400 cfu/100ml as a daily maximum value. However, Illinois EPA is using the instream water quality standard of 200 cfu/100ml as a geometric mean to develop fecal coliform WLAs for each of the permitted POTWs discharging to the impaired segment. The industrial facility do not have permit limits for fecal coliform and due to the nature of the process water being discharged, are not considered to have reasonable potential to discharge elevated concentrations of fecal coliform and therefore were not assigned WLAs for this parameter.

Each POTW facility's design maximum flow (DMF) was used to calculate the WLA during the highest 40% of in-stream flow conditions while the facility's design average flow (DAF) was used to calculate the WLA at lower stream flow levels (see discussion in **Section 2.3.1.5**). The use of the DMF in place of the more common DAF at higher flow conditions for each point source facility in the WLA calculations serves as an additional conservative measure in the TMDL calculations. This methodology essentially allows for each facility to use the entire treatment and discharge capacity available while still remaining within the WLA.

The DAFs and DMFs were multiplied by the geometric mean water quality standard of 200 cfu/100 ml for fecal coliform to establish the WLA for that facility, shown in **Table 2-4**. WLAs from point source discharges are applied to each discharge point for the segment receiving the discharge or the nearest impaired segment downstream of the discharge. WLAs are not calculated for additional impaired segments downstream of the receiving segment, as the segment nearest the discharge will mathematically have the least assimilative capacity, and the calculation of WLAs for this segment will be protective of all downstream segments.

Table 2-4: Fecal Coliform WLAs for NPDES Permitted Point Sources in the Thorn Creek Watershed

Facility	NPDES Permit Number	Applicable Stream Segment	DAF (MGD)	WLA-DAF (mil. col/Day)	DMF (MGD)	WLA-DMF (mil. col/Day)
Thorn Creek Basin Sanitary District STP	IL0027723	HBD-06	15.94	120,679	40.25	304,726
Aqua Illinois – University Park WWTF	IL0024473	HBDC	2.43	18,397	6.44	48,756
TCBSD - Homewood Excess Flow Treatment Plant	IL0029211	HBDB-03	--	--	18.5[1]	140,060
Park Forest Excess Flow Facility	IL0047562	HBD-05	--	--	2.8[2]	21,350
Ely's Mobile Home Park STP	IL0056065	HBDB-03	0.006	45	0.015	114
Paradise Park MHP	IL0026794	HBDA-01	0.064	485	0.16	1,211
Chicago Heights Steel	IL0001678	HBD-05	--	n/a[3]	--	n/a[3]
Mid-West Manufacturing LLC	IL0059421	HBD-05	--	n/a[3]	--	n/a[3]
Innophos Inc.	IL0035220	HBD-05	--	n/a[3]	--	n/a[3]
Hanson Material Service Yard 41	ILG840199	HBD-02	--	n/a[3]	--	n/a[3]
Park Forest WTP	ILG640194	HBD-05	--	n/a[3]	--	n/a[3]

[1] Maximum discharge rate when actively discharging within last five years, applied to high flow conditions only.
[2] Design flow of this facility.
[3] No effluent limit for fecal coliform for this facility, no reasonable potential for elevated fecal coliform concentrations in discharge.

The permitted effluent limit for fecal coliform at all of the POTWs in this watershed is currently based on the 400 cfu/100ml daily maximum standard (not to be exceeded by more than 10% of samples collected in a 30-day period), which is not the most conservative water quality standard applicable to these stream segments. The most stringent applicable standard, and the one used as a TMDL endpoint for this watershed is the 200 cfu/100ml monthly geometric mean water quality standard for fecal coliform was used to establish the WLA for each facility. This limit will be included as a requirement in future NPDES permits issued for these facilities.

Furthermore, under certain low stream flow conditions, the effluent discharge from the treatment facilities may represent the only source of flow in the receiving stream. Under these low flow conditions, large proportions of the discharge will be lost to evaporation and infiltration into the stream bed, limiting the potential for conveyance of discharged materials into downstream reaches. Because WLA calculations are based on the permitted flow for each facility, under low to mid-level flow conditions the WLA can be overestimated and the resulting calculations will show WLA exceeding the LC for the receiving stream. In this case, at flow levels where the WLA exceeds the LC, the WLA was set equal to the LC at that flow level and the resulting nonpoint source (LA) allowable loads are zero.

MS4 Discharges
MS4s represent runoff from municipal areas with separate stormwater sewer systems. MS4s are regulated discharges and therefore, are allocated through WLAs, rather than LAs. WLAs for MS4s are calculated by first determining the total area within a municipality's boundaries that lies within the target watershed using GIS analyses and geographic data for municipal boundaries from the U.S. Census Department (2000).

The proportion of total MS4 area to total watershed area was then calculated for each sub-watershed. This proportion was then used to migrate loads from previously calculated LAs for overland runoff to WLAs for MS4 areas in each flow category. This process effectively transfers MS4 load allocations for overland runoff from non-regulated sources described as LAs to the WLA for regulated sources of contaminants. As MS4 allocations are tied to overland runoff in urban areas, they are therefore related to higher flow conditions in the stream. As a result, the WLAs for MS4s are only applied to the upper 50% of flow categories (mid-range to high flows) for each segment. The total MS4 load allocations for fecal coliform that are applied to the proportion of each municipality within each impaired reach's subbasin are shown for each applicable flow **category in Tables 2-5 through 2-12.**

Table 2-5: WLA (mil col/Day) for MS4 Areas in Thorn Creek Segment HBD-02

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	6,100	178,008	72,848	47,627	34,116	26,977	-	-	-	-	-
Country Club Hills	ILR400177	173	5,066	2,073	1,355	971	768	-	-	-	-	-
Crete	ILR400321	3,920	114,391	46,813	30,606	21,924	17,336	-	-	-	-	-
Flossmoor	ILR400337	1,697	49,522	20,266	13,250	9,491	7,505	-	-	-	-	-
Ford Heights	ILR400191	1,110	32,400	13,259	8,669	6,210	4,910	-	-	-	-	-
Frankfort	ILR400194	70	2,050	839	548	393	311	-	-	-	-	-
Glenwood	ILR400344	1,746	50,951	20,851	13,632	9,765	7,722	-	-	-	-	-
Homewood	ILR400357	1,059	30,925	12,656	8,274	5,927	4,687	-	-	-	-	-
Lansing	ILR400373	1,835	53,575	21,925	14,334	10,268	8,119	-	-	-	-	-
Lynwood	ILR400380	2,990	87,277	35,717	23,352	16,727	13,227	-	-	-	-	-
Matteson	ILR400383	4,458	130,095	53,240	34,808	24,934	19,716	-	-	-	-	-
Monee	ILG870335	497	14,522	5,943	3,885	2,783	2,201	-	-	-	-	-
Olympia Fields	ILR400413	1,841	53,733	21,989	14,377	10,298	8,143	-	-	-	-	-
Park Forest	ILR400421	3,141	91,670	37,515	24,527	17,569	13,893	-	-	-	-	-
Sauk Village	ILR400441	2,445	71,368	29,206	19,095	13,678	10,816	-	-	-	-	-
South Chicago Heights	ILR400449	1,009	29,466	12,059	7,884	5,647	4,466	-	-	-	-	-
Steger	ILR400455	2,238	65,312	26,728	17,475	12,517	9,898	-	-	-	-	-
Thornton	ILR400459	949	27,699	11,336	7,411	5,309	4,198	-	-	-	-	-
University Park	ILR400250	4,622	134,886	55,200	36,090	25,852	20,442	-	-	-	-	-

Table 2-6: WLA (mil col/Day) for MS4 Areas in Thorn Creek Segment HBD-03

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Monee	ILG870335	407	18,996	7,087	4,062	2,550	1,793	-	-	-	-	-
Park Forest	ILR400421	1,054	49,214	18,360	10,523	6,605	4,646	-	-	-	-	-
University Park	ILR400250	2,471	115,319	43,020	24,658	15,477	10,887	-	-	-	-	-

Table 2-7: WLA (mil col/Day) for MS4 Areas in Thorn Creek Segment HBD-04

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	6,100	183,818	83,043	52,070	36,808	28,280	-	-	-	-	-
Country Club Hills	ILR400177	173	5,231	2,363	1,482	1,047	805	-	-	-	-	-
Crete	ILR400321	3,920	118,125	53,365	33,461	23,654	18,173	-	-	-	-	-
Flossmoor	ILR400337	1,697	51,139	23,103	14,486	10,240	7,867	-	-	-	-	-
Ford Heights	ILR400191	1,110	33,458	15,115	9,478	6,700	5,147	-	-	-	-	-
Frankfort	ILR400194	70	2,117	956	600	424	326	-	-	-	-	-
Glenwood	ILR400344	1,746	52,615	23,770	14,904	10,536	8,095	-	-	-	-	-
Homewood	ILR400357	1,059	31,934	14,427	9,046	6,395	4,913	-	-	-	-	-
Lansing	ILR400373	2,060	62,090	28,050	17,588	12,433	9,552	-	-	-	-	-
Lynwood	ILR400380	2,990	90,126	40,716	25,530	18,047	13,866	-	-	-	-	-
Matteson	ILR400383	4,458	134,342	60,692	38,055	26,901	20,668	-	-	-	-	-
Monee	ILG870335	497	14,996	6,775	4,248	3,003	2,307	-	-	-	-	-
Olympia Fields	ILR400413	1,841	55,487	25,067	15,718	11,111	8,536	-	-	-	-	-
Park Forest	ILR400421	3,141	94,663	42,766	26,815	18,956	14,563	-	-	-	-	-
Sauk Village	ILR400441	2,445	73,697	33,294	20,876	14,757	11,338	-	-	-	-	-
South Chicago Heights	ILR400449	1,009	30,428	13,746	8,619	6,093	4,681	-	-	-	-	-
South Holland	ILR400451	908	27,389	12,374	7,759	5,485	4,214	-	-	-	-	-
Steger	ILR400455	2,238	67,443	30,469	19,105	13,505	10,376	-	-	-	-	-
Thornton	ILR400459	1,154	34,791	15,718	9,855	6,967	5,353	-	-	-	-	-
University Park	ILR400250	4,622	139,288	62,926	39,457	27,892	21,429	-	-	-	-	-

Table 2-8: WLA (mil col/Day) for MS4 Areas in Thorn Creek Segment HBD-05

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	2,472	110,200	41,359	23,369	14,949	11,121	-	-	-	-	-
Matteson	ILR400383	52	2,318	870	492	314	234	-	-	-	-	-
Monee	ILG870335	407	18,144	6,809	3,848	2,461	1,831	-	-	-	-	-
Olympia Fields	ILR400413	75	3,330	1,250	706	452	336	-	-	-	-	-
Park Forest	ILR400421	2,817	125,564	47,125	26,627	17,033	12,672	-	-	-	-	-
South Chicago Heights	ILR400449	349	15,576	5,846	3,303	2,113	1,572	-	-	-	-	-
University Park	ILR400250	2,559	114,041	42,800	24,184	15,470	11,509	-	-	-	-	-

Table 2-9: WLA (mil col/Day) for MS4 Areas in Thorn Creek Segment HBD-06

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%[1]	20 - 30%[1]	30 - 40%[1]	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	4,925	92,496	0	0	0	6,270	-	-	-	-	-
Flossmoor	ILR400337	55	1,040	0	0	0	71	-	-	-	-	-
Glenwood	ILR400344	30	555	0	0	0	38	-	-	-	-	-
Matteson	ILR400383	52	977	0	0	0	66	-	-	-	-	-
Monee	ILG870335	407	7,645	0	0	0	518	-	-	-	-	-
Olympia Fields	ILR400413	75	1,408	0	0	0	95	-	-	-	-	-
Park Forest	ILR400421	2,817	52,911	0	0	0	3,587	-	-	-	-	-
South Chicago Heights	ILR400449	847	15,906	0	0	0	1,078	-	-	-	-	-
Steger	ILR400455	801	15,037	0	0	0	1,019	-	-	-	-	-
University Park	ILR400250	2,559	48,055	0	0	0	3,257	-	-	-	-	-

[1] All available WLA at these flow levels previously allocated to a point source discharge (Thorn Creek Basin Sanitary District STP).

Table 2-10: WLA (mil col/Day) for MS4 Areas in Butterfield Creek Segment HBDB-03

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	399	6,622	3,516	1,828	1,192	830	-	-	-	-	-
Country Club Hills	ILR400177	174	2,883	1,531	796	519	361	-	-	-	-	-
Flossmoor	ILR400337	1,642	27,269	14,476	7,527	4,907	3,417	-	-	-	-	-
Frankfort	ILR400194	70	1,167	619	322	210	146	-	-	-	-	-
Glenwood	ILR400344	448	7,440	3,949	2,053	1,339	932	-	-	-	-	-
Homewood	ILR400357	937	15,561	8,261	4,295	2,800	1,950	-	-	-	-	-
Matteson	ILR400383	4,406	73,189	38,853	20,201	13,171	9,171	-	-	-	-	-
Olympia Fields	ILR400413	1,766	29,341	15,576	8,098	5,280	3,677	-	-	-	-	-
Park Forest	ILR400421	324	5,382	2,857	1,486	969	674	-	-	-	-	-
University Park	ILR400250	896	14,877	7,898	4,106	2,677	1,864	-	-	-	-	-

Table 2-11: WLA (mil col/Day) for MS4 Areas in Deer Creek Segment HBDC

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%[1]	20 - 30%[1]	30 - 40%[1]	40 - 50%[1]	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Crete	ILR400321	805	12,212	0	0	0	0	-	-	-	-	-
Monee	ILG870335	91	1,374	0	0	0	0	-	-	-	-	-
Steger	ILR400455	271	4,114	0	0	0	0	-	-	-	-	-
University Park	ILR400250	942	14,294	0	0	0	0	-	-	-	-	-

[1] All available WLA at these flow levels previously allocated to a point source discharge (Aqua Illinois – University Park WWTF).

Table 2-12: WLA (mil col/Day) for MS4 Areas in Deer Creek Segment HBDC-02

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	776	19,262	6,421	3,596	2,337	1,875	-	-	-	-	-
Crete	ILR400321	3,830	95,063	31,688	17,745	11,534	9,253	-	-	-	-	-
Ford Heights	ILR400191	930	23,075	7,692	4,307	2,800	2,246	-	-	-	-	-
Glenwood	ILR400344	335	8,325	2,775	1,554	1,010	810	-	-	-	-	-
Lynwood	ILR400380	220	5,460	1,820	1,019	662	531	-	-	-	-	-
Monee	ILG870335	91	2,247	749	419	273	219	-	-	-	-	-
Sauk Village	ILR400441	703	17,436	5,812	3,255	2,116	1,697	-	-	-	-	-
South Chicago Heights	ILR400449	163	4,040	1,347	754	490	393	-	-	-	-	-
Steger	ILR400455	1,400	34,753	11,584	6,487	4,217	3,383	-	-	-	-	-
University Park	ILR400250	1,168	28,984	9,661	5,410	3,517	2,821	-	-	-	-	-

2.3.1.5 Reserve Capacity

A portion of the fecal coliform loading capacity may be set as a RC to allow for future population growth and development. In the case of Thorn Creek segments HBD-02, HBD-03, HBD-04, HBD-05, and HBD-06; Butterfield Creek segment HBDB-03; and Deer Creek segments HBDC and HBDC-02, an RC was included implicitly within the WLA. While the population within some portions of the Thorn Creek watershed is projected to increase between 2010 and 2040 (CMAP 2010), this increase has largely been anticipated by the POTWs in the watershed and is reflected in the design capacities permitted for each facility. The use of DMF in place of the more common DAF at higher flow conditions for each point source facility in the WLA calculations serve as conservative measures in the TMDL calculations and accounts for the population growth in the watershed as anticipated by the POTWs' facility plans. This methodology provides implicit RC for each facility and allows for the use of the entire treatment and discharge capacity available while still remaining within the WLA. Future growth requiring expansion above and beyond the current capacity of the POTWs discharging to this watershed is not anticipated at this time. Population growth in the watershed is not expected to directly impact fecal coliform contributions from non-point sources.

2.3.1.6 Load Allocation and TMDL Summary

Table 2-13 shows a summary of the fecal coliform TMDL for Thorn Creek segment HBD-02. This segment has one point source discharge, Paradise Park MHP STP (IL0026794) that was assigned a WLA for fecal coliform. This discharge has a relatively small flow, and its permitted design average and DMFs were used along with the WQS of 200 cfu/100ml as a geometric mean to calculate the WLAs. The remainder of the WLA applied to this segment's TMDL are related to the MS4 areas as discussed in **Section 2.3.1.4**. Under low flow and dry conditions, the calculated WLA does not include MS4s as these sources are precipitation and flow dependent.

Table 2-13: Fecal Coliform TMDL for Thorn Creek Segment HBD-02

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	1,935,457	711,329	1,224,128	implicit	200,396,851	99%
Moist	10 - 20	792,779	291,103	501,676	implicit	157,846,164	99%
	20 - 30	518,732	190,321	328,411	implicit	47,263,316	99%
	30 - 40	371,921	136,330	235,590	implicit	92,930,798	100%
Mid-Range	40 - 50	293,622	107,803	185,819	implicit	28,209,221	99%
Dry	50 - 60	244,685	244,200	485	implicit	1,945,244	87%
	60 - 70	210,429	209,944	485	implicit	509,923	59%
	70 - 80	171,279	170,795	485	implicit	2,278,461	92%
	80 - 90	141,917	141,433	485	implicit	984,103	86%
Low Flow	90 - 100	112,555	112,070	485	implicit	335,708	66%

[1] Actual Load was calculated using the 90th percentile of observed fecal coliform concentrations in a given flow range (USEPA 2007)

Table 2-14 shows a summary of the fecal coliform TMDL for Thorn Creek segment HBD-03. All of the WLA applied to this segment's TMDL are related to the MS4 areas discussed in **Section 2.3.1.4**. There are no permitted point sources in or upstream of segment HBD-03. Under low flow and dry conditions, the calculated WLA does not include MS4s as this source is precipitation and flow dependent.

Table 2-14: Fecal Coliform TMDL for Thorn Creek Segment HBD-03

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)[2]	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	262,042	78,513	183,529	implicit	15,996,847	98%
Moist	10 - 20	97,755	29,289	68,466	implicit	8,881,567	99%
	20 - 30	56,032	16,788	39,244	implicit	2,461,647	98%
	30 - 40	35,170	10,538	24,632	implicit	3,432,207	99%
Mid-Range	40 - 50	24,739	7,412	17,327	implicit	260,701	91%
Dry	50 - 60	16,047	16,047	0	implicit	240,099	93%
	60 - 70	10,831	10,831	0	implicit	1,788,294	99%
	70 - 80	7,354	7,354	0	implicit	N/A	N/A
	80 - 90	3,877	3,877	0	implicit	14,487	73%
Low Flow	90 - 100	400	400	0	implicit	1,797	78%

[1] Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (USEPA 2007)

[2] WLA for MS4s only applied in the mid to high flow categories, no other WLA required.

Table 2-15 shows a summary of the fecal coliform TMDL for Thorn Creek segment HBD-04. All of the WLA applied to this segment's TMDL are related to the MS4 areas discussed in **Section 2.3.1.4**. All of the individually permitted point sources in the watershed discharge to segments upstream of HBD-04 and are accounted for in TMDLs developed for the segment initially receiving the discharge. Under low flow and dry conditions, the calculated WLA does not include MS4s as this source is precipitation and flow dependent.

Table 2-15: Fecal Coliform TMDL for Thorn Creek Segment HBD-04

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)[2]	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	2,061,775	758,600	1,303,175	implicit	388,238,078	99%
Moist	10 - 20	931,449	342,713	588,736	implicit	138,131,393	99%
	20 - 30	584,044	214,890	369,153	implicit	17,275,109	97%
	30 - 40	412,859	151,905	260,953	implicit	6,640,477	94%
Mid-Range	40 - 50	317,196	116,708	200,489	implicit	2,570,296	88%
Dry	50 - 60	251,743	251,743	0	implicit	2,998,536	92%
	60 - 70	201,394	201,394	0	implicit	706,391	71%
	70 - 80	161,116	161,116	0	implicit	6,679,044	98%
	80 - 90	125,872	125,872	0	implicit	404,944	69%
Low Flow	90 - 100	95,662	95,662	0	implicit	216,499	56%

[1] Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (USEPA 2007)

[2] WLA for MS4s only applied in the mid to high flow categories, no other WLA required.

Table 2-16 shows a summary of the fecal coliform TMDL for Thorn Creek segment HBD-05. This segment has one point source discharge that contributes fecal coliform, Park Forest Excess Flow Facility (IL0047562). According to facility operators, the facility operates when the TCSD interceptor sewer flow is greater than 2.9 MGD and the DAF of the facility is 2.8 MGD. The permitted DMF was listed as "no limit" for the Park Forest Excess Flow Facility. In order to calculate the high flow WLA, the DAF of the facility was used (2.8 MGD), along with the 200cfu/100ml geometric mean water quality standard. The remainder of the permitted point sources in the watershed discharge to segments upstream of HBD-05 and are accounted for in TMDLs developed for the segment initially receiving the discharge. The remainder of the WLA applied to this segment's TMDL are related to the MS4 areas as discussed in **Section 2.3.1.4**. Under low flow and dry conditions, the calculated WLA does not include MS4s as these sources are precipitation and flow dependent.

Table 2-16: Fecal Coliform TMDL for Thorn Creek Segment HBD-05

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)[2]	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	527,607	117,086	410,521	implicit	138,670,055	100%
Moist	10 - 20	190,002	43,943	146,059	implicit	25,445,581	99%
	20 - 30	107,359	24,830	82,529	implicit	17,962,993	99%
	30 - 40	68,675	15,883	52,792	implicit	13,907,868	100%
Mid-Range	40 - 50	51,091	11,816	39,275	implicit	260,613	80%
Dry	50 - 60	33,508	33,508	0	implicit	994,653	97%
	60 - 70	22,957	22,957	0	implicit	339,795	93%
	70 - 80	12,407	12,407	0	implicit	325,546	96%
	80 - 90	5,374	5,374	0	implicit	204,433	97%
Low Flow	90 - 100	1,857	1,857	0	implicit	328,531	99%

[1] Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (USEPA 2007)
[2] WLA for MS4s only applied in the mid to high flow categories, no other WLA required.

A summary of the fecal coliform TMDL for Thorn Creek segment HBD-06 is provided in **Table 2-17**. This segment is an effluent dominated stream receiving much of its flow from the Thorn Creek Basin Sanitary District STP (IL0027723), particularly at lower flow levels. The WLA was calculated using the appropriate design flows for the facility and the 200cfu/100ml geometric mean water quality standard. Under some flow conditions, the calculated WLA from this point source alone is greater than the calculated LC, resulting in insufficient available WLA for the MS4 and zero available LA. In some lower flow categories that do not include MS4 loads, there is also insufficient LC to absorb the entire WLA from the Thorn Creek Basin Sanitary District STP and WLAs were set to the LC. These anomalies are a product of the disproportionally high discharge flows associated with using design flows under all stream flow conditions. In order to reconcile this and provide more accurate load allocation numbers, the WLA was set equal to the LC for these lower flow categories.

Table 2-17: Fecal Coliform TMDL for Thorn Creek Segment HBD-06

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	611,316	70,560	540,756	Implicit	103,443,719	99%
Moist	10 - 20	293,027	*	293,027	Implicit	42,720,361	99%
	20 - 30	207,140	*	207,140	Implicit	14,781,463	99%
	30 - 40	171,775	*	171,775	Implicit	3,544,368	95%
Mid-Range	40 - 50	141,461	4,783	136,679	Implicit	662,798	79%
Dry	50 - 60	126,305	5,626	120,679	Implicit	746,614	83%
	60 - 70	111,148	*	111,148	Implicit	1,259,007	91%
	70 - 80	106,096	*	106,096	Implicit	528,465	80%
	80 - 90	95,992	*	95,992	Implicit	230,380	58%
Low Flow	90 - 100	80,835	*	80,835	Implicit	461,415	82%

* Represents LA contributions.

[1] Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (USEPA 2007)

Table 2-18 shows a summary of the fecal coliform TMDL for Butterfield Creek segment HBDB-03. This segment has two point source discharges, Homewood Excess Flow Treatment Plant (IL0029211) and Ely's Mobile Home Park STP (IL56065) that were assigned a WLA for fecal coliform discharges to this segment. The Homewood facility operates at high flows, when Thorn Creek Basin Sanitary District STP is receiving its maximum practical flow. The permitted DMF was listed as "no limit" for the Homewood Excess Flow Treatment Plant. In order to calculate the high flow WLA, the highest recorded facility flow of the past five years was used (18.5 MGD), along with the 200 cfu/100ml geometric mean water quality standard. Ely's Mobile Home Park STP has a relatively small flow, and its permitted design average and design maximum flows were used along with the 200 cfu/100ml geometric mean water quality standard to calculate the WLAs. The remainder of the WLA applied to this segment's TMDL are related to the MS4 areas as discussed in **Section 2.3.1.4**. Under low flow and dry conditions, the calculated WLA does not include MS4s as these sources are precipitation and flow dependent.

Table 2-18: Fecal Coliform TMDL for Butterfield Creek Segment HBDB-03

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	414,235	90,329	323,906	implicit	155,120,577	100%
Moist	10 - 20	145,602	47,952	97,650	implicit	15,939,963	99%
	20 - 30	75,757	24,932	50,826	implicit	5,655,409	99%
	30 - 40	49,431	16,255	33,177	implicit	7,045,649	99%
Mid-Range	40 - 50	34,388	11,319	23,069	implicit	11,789,650	100%
Dry	50 - 60	24,717	24,672	45	implicit	144,838	83%
	60 - 70	18,807	18,762	45	implicit	34,292	45%
	70 - 80	13,435	13,389	45	implicit	48,149	72%
	80 - 90	10,480	10,434	45	implicit	170,810	94%
Low Flow	90 - 100	5,215	5,169	45	implicit	97,242	95%

[1] Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (USEPA 2007)

Table 2-19 shows a summary of the fecal coliform TMDL for Deer Creek segment HBDC. This segment has one point source discharge, Aqua Illinois – University Park WWTF (IL0024473) that was assigned a WLA for fecal coliform discharges to this segment. Its permitted design average and design maximum flows were used along with the 200 cfu/100ml geometric mean water quality standard to calculate the WLAs. Under all but the "high" flow conditions, the calculated WLA from this point source alone is greater than the calculated LC, resulting in insufficient available WLA for the MS4 and zero available LA. In all but the "high" flow categories, the WLAs were set to the LC. These anomalies are a product of the disproportionally high discharge flows associated with using design flows under all stream flow conditions. The remainder of the WLA under "high" flow conditions applied to this segment's TMDL are related to the MS4 areas as discussed in **Section 2.3.1.4**.

Table 2-19: Fecal Coliform TMDL for Deer Creek Segment HBDC

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	124,757	44,007	80,750	implicit	3,519,648	96%
Moist	10 - 20	41,310	*	41,310	implicit	95,530	57%
	20 - 30	23,134	*	23,134	implicit	353,815	93%
	30 - 40	15,037	*	15,037	implicit	26,195	43%
Mid-Range	40 - 50	11,732	*	11,732	implicit	1,405,430	99%
Dry	50 - 60	9,749	*	9,749	implicit	526,106	98%
	60 - 70	7,932	*	7,932	implicit	17,350	54%
	70 - 80	6,444	*	6,444	implicit	1,648	N/A
	80 - 90	5,122	*	5,122	implicit	124,564	96%
Low Flow	90 - 100	3,470	*	3,470	implicit	8,946	61%

* Represents LA contributions.
[1] Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (USEPA 2007)

Table 2-20 shows a summary of the fecal coliform TMDL for Deer Creek segment HBDC-02. All of the WLA applied to this segment's TMDL are related to the MS4 areas discussed in **Section 2.3.1.4**. All of the individually permitted point sources in the watershed discharge to segments upstream of HBDC-02 and are accounted for in TMDLs developed for the segment initially receiving the discharge. Under low flow and dry conditions, the calculated WLA does not include MS4s as this source is precipitation and flow dependent.

Table 2-20: Fecal Coliform TMDL for Deer Creek Segment HBDC-02

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA (mil col/day)	MOS	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	421,049	182,403	238,646	implicit	77,238,544	99%
Moist	10 - 20	140,350	60,801	79,549	implicit	1,178,936	88%
	20 - 30	78,596	34,049	44,547	implicit	1,311,271	94%
	30 - 40	51,087	22,132	28,956	implicit	56,952	10%
Mid-Range	40 - 50	40,982	17,754	23,228	implicit	11,030,461	100%
Dry	50 - 60	33,122	33,122	0	implicit	213,293	84%
	60 - 70	27,509	27,509	0	implicit	141,627	81%
	70 - 80	21,895	21,895	0	implicit	7,565	N/A
	80 - 90	17,403	17,403	0	implicit	146,991	88%
Low Flow	90 - 100	11,789	11,789	0	implicit	51,358	77%

[1] Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (USEPA 2007)

[2] WLA allocations for MS4s only applied in the mid to high flow categories, no other WLA required.

2.3.2 Chloride TMDL

Thorn Creek Segments HBD-04 and HBD-06 are each listed for impairment caused by elevated chloride concentrations.

Only one exceedance (sample collected February 22, 2010) to the water quality standard has been reported at Segment HBD-06 out of 113 samples collected since 2000 (see Figure 1-15). In fact, Segment HBD-06 has only one impairment out of 325 samples since 1982. Prior data from 1970 – 1982 shows that there were 6 impairments from the mid-1970's to the early 1980's, so an impairment may have existed at this time. A grab sample has been collected most months on this segment from the early 1970's to 2012, for a total of 463 samples, so ample data exists. It seems that therefore that there is insufficient indication that this segment is currently impaired by chloride anymore, and therefore this segment is recommended for delisting for impairment caused by chloride.

A load duration curve was developed for the impaired segment HBD-04 (see **Section 1**) to determine load reductions needed to meet the instream water quality standard of 500 mg/L chloride across the full range of recorded flow levels.

2.3.2.1 Loading Capacity

The LC is the maximum quantity of chloride that the impaired segment can receive and still maintain compliance with the water quality standard. In order to determine the LC at various flow conditions, a range of flows were multiplied by the water quality standard (500 mg/L). **Table 2-21** contains the LCs for chloride under a range of flow conditions.

2.3.2.2 Seasonal Variation

Consideration to seasonality is inherent to load duration analysis. The total chloride water quality standard is not seasonal and the full range of expected flows is represented in the loading capacity table (**Table 2-21**). Therefore, the LC represents conditions throughout the year.

2.3.2.3 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions), or explicit (expressed in the TMDL as a portion of the loadings), or a combination of both. An explicit MOS for the total chloride TMDL of 10% was included to account for some of the limited site-specific data available within the watershed. Ten percent is generally considered adequate to compensate for any uncertainty in the TMDLs developed using this methodology because the use of the load duration curve approach minimizes a great deal of uncertainty as the calculation of the loading capacity is simply a function of flow multiplied by the target value. Most of the uncertainty in the calculations is therefore associated with the estimated flows in the assessed segments which were based on extrapolating flows from a surrogate USGS gauge. The methodology employed in estimating watershed flows is discussed in **Section 1.5.2** of this document.

Table 2-21: Estimated Chloride Loading Capacities Under Various Flow Conditions for Streams in the Thorn Creek Watershed

Estimated Mean Daily Flow (cfs)	Load Capacity (lbs/day)
5	13,484
10	26,969
50	134,844
100	269,689
500	1,348,443
1,000	2,696,886
5,000	13,484,428
10,000	26,968,857
15,000	40,453,285

2.3.2.4 Waste Load Allocation

As with the fecal coliform TMDLs, the WLAs for chloride TMDLs apply to individually permitted facilities and MS4s that exist in the Thorn Creek watershed, as described below.

Individual NPDES permitted facilities

Only one permittee is close enough to segment HBD-04 to impact its chloride concentration (Thorn Creek Basin Sanitary District STP). This facility currently has no permit limits for chloride. The chloride instream water quality standard of 500 mg/L was combined with the facility's DAF and DMF to assign WLAs for this discharge. Details for chloride for this NPDES permit and the direct receiving segment is provided in **Table 2-22**.

Table 2-22: Chloride WLAs for NPDES Permitted Point Sources in the Thorn Creek Watershed

Facility	NPDES Permit Number	Applicable Stream Segment	DAF (MGD)	WLA-DAF (lbs/Day)	DMF (MGD)	WLA-DMF (lbs/Day)
Thorn Creek Basin Sanitary District STP	IL0027723	HBD-04	15.94	66,512	40.25	167,949

MS4 Discharges

MS4 discharges represent runoff from municipal areas with separate stormwater sewer systems. MS4 discharges are regulated discharges and therefore, are allocated through WLAs, rather than

LAs. Chloride WLAs for MS4s were calculated in a manner consistent with the calculations performed for fecal coliform TMDLs (see **section 2.3.1.4**). The total MS4 load allocations for chloride that are applied to each municipality within each impaired reach's subbasin are shown for each applicable flow category in **Table 2-23.**

Table 2-23: WLA (lbs/Day) for MS4 Areas in Thorn Creek Segment HBD-04

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	6,100	88,225	24,661	8,852	2,172	7,430	-	-	-	-	-
Country Club Hills	ILR400177	174	2,425	702	252	62	211	-	-	-	-	-
Crete	ILR400321	3,920	54,767	15,847	5,688	1,396	4,775	-	-	-	-	-
Flossmoor	ILR400337	1,697	23,710	6,861	2,463	604	2,067	-	-	-	-	-
Ford Heights	ILR400191	1,110	15,512	4,489	1,611	395	1,352	-	-	-	-	-
Frankfort	ILR400194	70	981	284	102	25	86	-	-	-	-	-
Glenwood	ILR400344	1,746	24,394	7,059	2,534	622	2,127	-	-	-	-	-
Homewood	ILR400357	1,060	14,806	4,284	1,538	377	1,291	-	-	-	-	-
Lansing	ILR400373	2,060	28,787	8,330	2,990	734	2,510	-	-	-	-	-
Lynwood	ILR400380	2,991	41,786	12,091	4,340	1,065	3,643	-	-	-	-	-
Matteson	ILR400383	4,458	62,286	18,023	6,469	1,587	5,430	-	-	-	-	-
Monee	ILG870335	498	6,953	2,012	722	177	606	-	-	-	-	-
Olympia Fields	ILR400413	1,841	25,726	7,444	2,672	656	2,243	-	-	-	-	-
Park Forest	ILR400421	3,141	43,889	12,700	4,558	1,118	3,826	-	-	-	-	-
Sauk Village	ILR400441	2,446	34,169	9,887	3,549	871	2,979	-	-	-	-	-
South Chicago Heights	ILR400449	1,010	14,108	4,082	1,465	359	1,230	-	-	-	-	-
South Holland	ILR400451	909	12,699	3,675	1,319	324	1,107	-	-	-	-	-
Steger	ILR400455	2,238	31,270	9,048	3,248	797	2,726	-	-	-	-	-
Thornton	ILR400459	1,155	16,131	4,668	1,675	411	1,406	-	-	-	-	-
University Park	ILR400250	4,622	64,580	18,687	6,707	1,646	5,630	-	-	-	-	-

2.3.2.5 Reserve Capacity

In the case of the chloride TMDL, an explicit RC was not included in the TMDL calculations due to the lack of point source loading of chloride from facilities directly impacted by population change believed to be occurring in the watershed. Non-point loads of chloride are not expected to increase as a result of typical levels of population growth anticipated within this watershed.

2.3.2.6 Load Allocation and TMDL Summary

Table 2-24 shows the summary of the chloride TMDL for segment HBD-04. This segment has one tributary point source discharge, Thorn Creek Basin Sanitary District STP (IL0027723) that was assigned a WLA for chloride discharges to this segment. This discharger's permitted design average and design maximum flows were used along with the 500 mg/L limit to calculate the WLAs. The remainder of the WLA applied to this segment's TMDL is related to the MS4 areas as discussed in **Section 2.3.2.4**. Under low flow and dry conditions, the calculated WLA does not include MS4s as these sources are precipitation and flow dependent. Although individual samples collected in this segment have exceeded the instream water quality standard on several occasions, exceedences are relatively infrequent (approximately 2.6% of all samples) and do not result in a calculated percent reduction (based on the 90th percentile of recorded concentrations in each flow category) needed from any of the flow categories.

Table 2-24: Chloride TMDL for Thorn Creek (HBD-04)

Zone	Flow Exceedance Range (%)	LC (lbs/day)	LA (lbs/day)	WLA (lbs/day)	MOS - 10% of LC (lbs/day)	Actual Load[1] (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	1,248,747	351,718	772,154	124,875	816,132	None
Moist	10 - 20	493,949	101,773	342,781	49,395	256,731	None
	20 - 30	296,924	36,530	230,702	29,692	209,183	None
	30 - 40	213,675	8,962	183,346	21,367	161,817	None
Mid-Range	40 - 50	166,500	30,663	119,187	16,650	89,488	None
Dry	50 - 60	138,750	58,363	66,512	13,875	79,022	None
	60 - 70	116,550	38,383	66,512	11,655	64,389	None
	70 - 80	97,125	20,901	66,512	9,712	46,869	None
	80 - 90	80,475	5,916	66,512	8,047	53,732	None
Low Flow	90 - 100	66,600	0	59,940	6,660	26,844	None

[1] Actual Load was calculated using the 90th percentile of observed chloride concentrations in a given flow range (USEPA 2007)

2.3.3 Zinc TMDL

Thorn Creek Segment HBD-02 is listed for impairment caused by elevated zinc concentrations. Sources of zinc can include point sources and nonpoint sources. Common nonpoint sources include aging galvanized iron and steel, road salt, tire wear, and it occurs naturally bound to soils and enters streams through erosion (Schueler and Shepp 1993). Sources of zinc are also discussed in Section 3.9. A load duration curve was developed for this impaired segment (see **Section 1**) to determine load reductions needed to meet the instream chronic water quality standard of 93 µg/L zinc (dissolved) across the full range of recorded flow levels.

Table 2-25: Estimated Dissolved Zinc Loading Capacities Under Various Flow Conditions for Streams in the Thorn Creek Watershed

Estimated Mean Daily Flow (cfs)	Load Capacity (lbs/day)
5	1.74
10	3.48
50	17.4
100	34.8
500	174
1,000	348
5,000	1,740
10,000	3,480
15,000	5,230

2.3.3.1 Loading Capacity

The LC is the maximum quantity of dissolved zinc that the impaired segment can receive and still maintain compliance with the water quality standard. In order to determine the LC at various flow conditions, a range of flows were multiplied by the water quality standard (93 µg/L). **Table 2-25** contains the LCs for dissolved zinc under a range of flow conditions.

2.3.3.2 Seasonal Variation

Consideration to seasonality is inherent to load duration analysis. The dissolved zinc water quality standard is not seasonal and the full range of expected flows is represented in the LC table (**Table 2-25**). Therefore, the LC represents conditions throughout the year.

2.3.3.3 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions), or explicit (expressed in the TMDL as a portion of the loadings), or a combination of both. An explicit MOS for the dissolved zinc TMDL of 10% was included to account for some of the limited site-specific data available within the watershed. A low rate of uncertainty in the calculations is associated with the estimated flows in the assessed segments which were based on extrapolating flows from a surrogate USGS gauge. The methodology employed in estimating watershed flows is discussed in **Section 1.5.2** of this document.

2.3.3.4 Waste Load Allocation

As with the fecal coliform TMDLs, the WLAs for dissolved zinc TMDLs apply to individually permitted facilities and MS4s that exist in the Thorn Creek watershed, as described below.

<u>Individual NPDES permitted facilities</u>

There are no individual NPDES permitted facilities that discharge directly to the impaired segment that have a reasonable potential for elevated zinc concentrations in their discharge. However, Aqua Illinois – University Park WWTF (IL0024473) has a permitted zinc limit, and is located approximately 13 miles upstream of the impaired segment. Hanson Material Service Yard

41 (ILG840199) is a general construction permit within the subbasin, but is unlikely to discharge elevated zinc concentrations and has no zinc permit limit.

Aqua Illinois – University Park WWTF's design maximum flow (DMF) was used to calculate the WLA during the highest 40% of in-stream flow conditions while the facility's design average flow (DAF) was used to calculate the WLA at lower stream flow levels (see discussion in **Section 2.3.1.5**). The use of the DMF in place of the more common DAF at higher flow conditions in the WLA calculations serves as an additional conservative measure in the TMDL calculations. This methodology essentially allows for the facility to use the entire treatment and discharge capacity available while still remaining within the WLA.

The DAFs and DMFs were multiplied by Aqua Illinois – University Park WWTF's monthly average concentration limit for zinc of 0.079 mg/L to establish the WLA for that facility, shown in **Table 2-26**.

Table 2-26: Zinc WLAs for NPDES Permitted Point Sources in the Thorn Creek Watershed

Facility	NPDES Permit Number	Applicable Stream Segment	DAF (MGD)	WLA-DAF (lbs/Day)	DMF (MGD)	WLA-DMF (lbs/Day)
Aqua Illinois – University Park WWTF	IL0024473	HBD-06	2.43	1.60	6.44	4.2

<u>MS4 Discharges</u>

MS4 discharges represent runoff from municipal areas with separate stormwater sewer systems. MS4 discharges are regulated discharges and therefore, are allocated through WLAs, rather than LAs. Zinc WLAs for MS4s were calculated in a manner consistent with the calculations performed for fecal coliform TMDLs (see **section 2.3.1.4**). The total MS4 load allocations for zinc that are applied to each municipality within the impaired reach's subbasin are shown for each applicable flow category in **Table 2-27.**

Table 2-27: WLA (lbs/Day) for MS4 Areas in Thorn Creek Segment HBD-02

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Chicago Heights	ILR400174	6,100	18.02	6.96	4.18	2.89	2.43	-	-	-	-	-
Country Club Hills	ILR400177	174	0.51	0.20	0.12	0.08	0.07	-	-	-	-	-
Crete	ILR400321	3,920	11.58	4.48	2.69	1.86	1.56	-	-	-	-	-
Flossmoor	ILR400337	1,697	5.01	1.94	1.16	0.80	0.68	-	-	-	-	-
Ford Heights	ILR400191	1,110	3.28	1.27	0.76	0.53	0.44	-	-	-	-	-
Frankfort	ILR400194	70	0.21	0.08	0.05	0.03	0.03	-	-	-	-	-
Glenwood	ILR400344	1,746	5.16	1.99	1.20	0.83	0.70	-	-	-	-	-
Homewood	ILR400357	1,060	3.13	1.21	0.73	0.50	0.42	-	-	-	-	-
Lansing	ILR400373	1,836	5.42	2.10	1.26	0.87	0.73	-	-	-	-	-
Lynwood	ILR400380	2,991	8.83	3.41	2.05	1.42	1.19	-	-	-	-	-
Matteson	ILR400383	4,458	13.17	5.09	3.05	2.11	1.78	-	-	-	-	-
Monee	ILG870335	498	1.47	0.57	0.34	0.24	0.20	-	-	-	-	-

Municipality	NPDES ID	MS4 Area in Watershed (acres)	High	Moist			Mid-Range	Dry				Low Flow
			0 - 10%	10 - 20%	20 - 30%	30 - 40%	40 - 50%	50 - 60%	60 - 70%	70 - 80%	80 - 90%	90 - 100%
Olympia Fields	ILR400413	1,841	5.44	2.10	1.26	0.87	0.73	-	-	-	-	-
Park Forest	ILR400421	3,141	9.28	3.59	2.15	1.49	1.25	-	-	-	-	-
Sauk Village	ILR400441	2,446	7.22	2.79	1.68	1.16	0.97	-	-	-	-	-
South Chicago Heights	ILR400449	1,010	2.98	1.15	0.69	0.48	0.40	-	-	-	-	-
Steger	ILR400455	2,238	6.61	2.56	1.53	1.06	0.89	-	-	-	-	-
Thornton	ILR400459	949	2.80	1.08	0.65	0.45	0.38	-	-	-	-	-
University Park	ILR400250	4,622	13.65	5.28	3.17	2.19	1.84	-	-	-	-	-

2.3.3.5 Reserve Capacity

An explicit RC was not included in the TMDL calculations for zinc due to the lack of point source loading of this constituent from facilities directly impacted by changes to population or increased development within the watershed. Non-point loads of zinc are also not expected to increase as a result of the population growth anticipated for this watershed.

2.3.3.6 Load Allocations and TMDL Summaries

Table 2-28 shows the summary of the zinc TMDL for segment HBD-02, along with the percent reductions required at various flow levels. This segment has one tributary point source discharge, Aqua Illinois – University Park WWTF (IL0024473) that was assigned a WLA for zinc discharges to this segment. This discharger's permitted design average and design maximum flows were used along with the 93 µg/L permitted effluent limit to calculate the WLAs. The remainder of the WLA applied to this segment's TMDL are related to the MS4 areas as discussed in **Section 2.3.3.4**. Under low flow and dry conditions, the calculated WLA does not include MS4s as these sources are precipitation and flow dependent.

Table 2-28: Zinc TMDL for Thorn Creek (HBD-02)

Zone	Flow Exceedance Range (%)	LC (lbs/day)	LA (lbs/day)	WLA (lbs/day)	MOS - 10% of LC (lbs/day)	Actual Load[1] (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	222	72	128	22.22	335	34%
Moist	10 - 20	89	28	52	8.88	126	30%
	20 - 30	55	17	33	5.52	63	12%
	30 - 40	40	12	24	3.96	42	6%
Mid-Range	40 - 50	31	10	18	3.11	37	16%
Dry	50 - 60	25	21	1.60	2.46	28	13%
	60 - 70	21	17	1.60	2.06	24	13%
	70 - 80	17	14	1.60	1.71	19	10%
	80 - 90	15	12	1.60	1.51	17	10%
Low Flow	90 - 100	12	9	1.60	1.20	14	14%

[1] Actual Load was calculated using the 90th percentile of observed zinc concentrations in a given flow range (USEPA 2007)

2.3.4 Silver TMDL

Thorn Creek Segment HBD-02 is listed for impairment caused by elevated silver concentrations. A load duration curve was developed for this impaired segment (see **Section 1**) to determine load reductions needed to meet the instream water quality standard of 5 µg/L silver (total) across the full range of recorded flow levels.

Delisting for Segment HBD-02 should be considered, since only one exceedance to the water quality standard occurred out of the 158 samples taken (see Figure 1-17).

Only one exceedance (sample collected June 5, 1987) to the water quality standard has been reported at Segment HBD-02 out of 158 samples collected (see Figure 1-17). It seems that therefore that there is insufficient indication that this segment is impaired by silver, and therefore this segment is recommended for delisting for impairment caused by silver.

2.3.5 Dissolved Oxygen in Streams

Six of the nine impaired stream segments within the Thorn Creek watershed are listed for impairment caused by low DO (Thorn Creek HBD-02, HBD-03, HBD-04 and HBD-06; North Creek HBDA-01; and Deer Creek HBDC-02). As discussed in **Section 1** of this report, a single, combined QUAL2K water quality model was developed to address the impaired segments. The combined QUAL2K model was developed to determine load reductions of oxygen-demanding materials needed to meet the 5.0 mg/L instantaneous minimum standard (March – July).

2.3.5.1 Loading Capacity

The LC for DO impairments is the maximum amount of oxygen-demanding material that Thorn Creek segments HBD-02, HBD-03, HBD-04 and HBD-06; North Creek segment HBDA-01; and Deer Creek segment HBDC-02 can receive and still maintain compliance with the water quality standards. Oxygen-demanding material here refers to total ammonia, total phosphorus, CBOD, SOD, and other oxygen-demanding materials. The allowable loads of oxygen-demanding material that can be generated in the Thorn Creek watershed, and still maintain the 5.0 mg/L water quality standard were analyzed using the calibrated model described in **Section 1**.

2.3.5.2 Seasonal Variation

Seasonality is addressed because the TMDL has been calculated during the time of year when DO will be at the lowest concentrations. This is the critical condition that represents the worst case scenario, and is therefore the most conservative way to calculate this TMDL.

2.3.5.3 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions), or explicit (expressed in the TMDL as a portion of the loadings), or a combination of both. An explicit MOS for the DO TMDL of 10% was included to account for some of the limited site-specific data available within the watershed.

2.3.5.4 Waste Load Allocation

WLAs for DO TMDLs are applied to individually permitted facilities and MS4s that exist in the watershed, as described below.

Individual NPDES permitted facilities

Four individual NPDES permitted dischargers within the Thorn Creek watershed discharge to the segments impaired for DO - Thorn Creek Basin Sanitary District STP, Paradise Park MHP, Hanson Material Service Yard 41, and Village of Lynwood CCDD. Details for oxygen-demanding materials, and ammonia-nitrogen, on each NPDES permit and the directly impacted segments are provided in **Table 2-29**. Two of the dischargers (Hanson Material Service Yard 41 and Village of Lynwood CCDD) are stormwater permits and do not have reasonable potential to discharge elevated concentrations of CBOD, NBOD (ammonia, nitrogen) and therefore were not assigned a WLA for this parameter.

Thorn Creek Basin Sanitary District STP and the Paradise Park MHP have permitted load limits for ammonia nitrogen (ammonia-N), which are included in **Table 2-29** and in the WLAs for the relevant impaired segment. Both facilities have permit limits for ammonia-N that vary seasonally. As the QUAL2K modeling effort focuses on the most critical period for low DO in streams of late summer, the applicable load limit for the month of August was applied for each permit. For both dischargers, a phosphorus limit of 1.0 mg/L was used as a model input, since this is the limit that has been assigned to another discharger in the watershed, Aqua Illinois – University Park WWTP; however, as there is no instream numeric water quality standard for CBOD or total phosphorus in Illinois, explicit WLA were not assigned for these parameters.

Table 2-29: Ammonia-N WLAs for NPDES Permitted Point Sources in the Thorn Creek Watershed

Facility	NPDES Permit Number	Applicable Stream Segment	Design Average Flow (MGD)	Ammonia-N WLA-DAF (lbs/day)	CBOD WLA-DAF (lbs/day)	Total Phosphorus WLA-DAF (lbs/day)
Thorn Creek Basin Sanitary District STP	IL0027723	HBD-06	15.94	226	n/a[1]	n/a[1]
Paradise Park MHP	IL0026794	HBDA-01	0.064	0.8	n/a[1]	n/a[1]
Hanson Material Service Yard 41	ILG840199	HBD-02	Intermittent	n/a[2]	n/a[1]	n/a[1]

[1] Instream numeric water quality standard does not exist, explicit WLAs were not assigned for this parameter
[2] No effluent limit for ammonia for this facility, no reasonable potential for elevated concentrations in discharge.

MS4 Discharges

MS4s represent runoff from municipal areas with separate stormwater sewer systems. MS4s contribute a significant amount of nutrients and oxygen-demanding material, including BOD, SOD and TSS. MS4s are regulated discharges and therefore, are allocated through WLAs, rather than LAs. WLAs for MS4s are calculated for parameters with numeric water quality standards by first determining the total area within a municipality's boundaries that lies within the target watershed using GIS analyses and geographic data for municipal boundaries from the U.S. Census Department (2000).

The proportion of total MS4 area to total watershed area was then calculated for each sub-watershed. This proportion was then used to migrate loads from previously calculated LAs for overland runoff to WLAs for MS4 areas during the critical annual flow condition (**Table 2-30**). This process effectively transfers MS4 load allocations for parameters with numeric water quality standards from non-regulated sources described as LAs to the WLA for regulated sources of contaminants.

Table 2-30 Ammonia-N WLAs for MS4s Permittees in the Thorn Creek Watershed

MS4 Permittee	NPDES ID	Ammonia-N WLA-DAF (lbs/day)						Total Ammonia-N MS4 WLA (lbs/day)
		HBD-02	HBD-03	HBD-04	HBD-06	HBDA-01	HBDC-02	
Chicago Heights	ILR400174	56.6	-	68.6	85.0	-	1.86	212
Country Club Hills	ILR400177	1.61	-	1.95	-	-	-	3.56
Crete	ILR400321	36.4	-	44.1	-	0.05	9.16	89.7
Flossmoor	ILR400337	15.8	-	19.1	0.96	-	-	35.8
Ford Heights	ILR400191	10.3	-	12.5	-	0.11	2.22	25.1
Frankfort	ILR400194	0.65	-	0.79	-	-	-	1.44
Glenwood	ILR400344	16.2	-	19.6	0.51	0.25	0.80	37.4
Homewood	ILR400357	9.84	-	11.9	-	-	-	21.7
Lansing	ILR400373	17.0	-	23.2	-	1.09	-	41.3
Lynwood	ILR400380	27.8	-	33.6	-	1.65	0.53	63.5
Matteson	ILR400383	41.4	-	50.1	0.90	-	-	92.4
Monee	ILG870335	4.62	11.6	5.59	7.03	-	0.22	29.0
Olympia Fields	ILR400413	17.1	-	20.7	1.29	-	-	39.1
Park Forest	ILR400421	29.2	30.0	35.3	48.6	-	-	143
Sauk Village	ILR400441	22.7	-	27.5	0.00	1.03	1.68	52.9
South Chicago Heights	ILR400449	9.37	0.04	11.3	14.6	-	0.39	35.8
South Holland	ILR400451	-	-	10.2	0.00	-	-	10.2
Steger	ILR400455	20.8	-	25.2	13.8	0.02	3.35	63.1
Thornton	ILR400459	8.81	-	13.0	-	-	-	21.8
University Park	ILR400250	42.9	70.3	51.9	44.2	-	2.79	212
Total		**389**	**112**	**486**	**217**	**4.2**	**23.0**	**1,231**

2.3.5.5 Reserve Capacity

An explicit RC was included in the TMDL calculations for DO to account for the projected population growth in the watershed. Due to the considerable uncertainty in the impact to loads of the constituents related to DO as a result of projected changes to population or increased development within the watershed, an RC of 10% of the overall LC was selected and applied to each constituent for each impaired reach. The 10% figure roughly equates to the projected population growth within the watershed over the next 10 years (CMAP 2010).

2.3.5.6 Load Allocations and TMDL Summary

Tables 2-31, 2-32, 2-33, 2-34, **2-35**, and **2-36** show a summary of the DO TMDLs for Thorn Creek segments HBD-03, HBD-06 and HBD-02, HBD-04, Deer Creek segment HBDC-02, and North Creek segment HBDA-01, respectively. These segments have no point source discharges assigned a WLA. The WLAs applied to these segments' TMDLs are related to the MS4 areas as discussed in **Section 2.3.5.4**. Phosphorus and overall phosphorus reductions are included without explicit WLAs as a result of the lack of an applicable water quality standard for the receiving waterbodies. As reductions in ammonia and phosphorus will directly reduce the organic and inorganic nutrient loading to the sediment bed, SOD was reduced proportionate to ammonia and phosphorus reductions, and not considered a separate pollutant. Percent reductions are based on actual loads vs. loading capacity less the reserve capacity.

Table 2-31: Dissolved Oxygen (SOD, CBOD, Ammonia, and Phosphorus) TMDL for Thorn Creek Segment HBD-03

Pollutant	LC (lbs/day)	LA (lbs/day)	WLA- Facilities (lbs/day)	WLA - MS4s (lbs/day)	MOS - 10% of LC (lbs/day)	RC - 10% of LC (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
Total Ammonia	178	30	-	112	17.8	18	550	71%
Total Phosphorus	57	45	n/a[1]	n/a[1]	5.7	5.7	175	71%
CBOD	4.2	3.4	n/a[1]	n/a[1]	0.4	0.4	11	64%
SOD (gO2/m2/d)	0.7	n/a				0.07	2.0	69%

[1] Instream numeric water quality standard does not exist, explicit WLA not assigned for this parameter

Table 2-32: Dissolved Oxygen (SOD, CBOD, Ammonia, and Phosphorus) TMDL for Thorn Creek Segment HBD-06

Pollutant	LC (lbs/day)	LA (lbs/day)	WLA- Facilities (lbs/day)	WLA - MS4s (lbs/day)	MOS - 10% of LC (lbs/day)	RC - 10% of LC (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
Total Ammonia	565	8	226	217	57	57	1,287	60%
Total Phosphorus	108	86	n/a[1]	n/a[1]	11	11	473	79%
CBOD	2,963	2,371	n/a[1]	n/a[1]	296	296	2,680	0.5%
SOD (gO2/m2/d)	0.7	n/a				0.07	2.0	69%

[1] Instream numeric water quality standard does not exist, explicit WLA not assigned for this parameter

Table 2-33: Dissolved Oxygen (SOD, CBOD, Ammonia, and Phosphorus) TMDL for Thorn Creek Segment HBD-02

Pollutant	LC (lbs/day)	LA (lbs/day)	WLA- Facilities (lbs/day)	WLA - MS4s (lbs/day)	MOS - 10% of LC (lbs/day)	RC - 10% of LC (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
Total Ammonia	683	158	-	389	68	68	1,593	61%
Total Phosphorus	303	243	n/a[1]	n/a[1]	30	30	575	53%
CBOD	2,968	2,374	n/a[1]	n/a[1]	297	297	2,689	0.6%
SOD (gO2/m2/d)	0.7	n/a				0.07	2.0	69%

[1] Instream numeric water quality standard does not exist, explicit WLA not assigned for this parameter

Table 2-34: Dissolved Oxygen (SOD, CBOD, Ammonia, and Phosphorus) TMDL for Thorn Creek Segment HBD-04

Pollutant	LC (lbs/day)	LA (lbs/day)	WLA- Facilities (lbs/day)	WLA - MS4s (lbs/day)	MOS - 10% of LC (lbs/day)	RC - 10% of LC (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
Total Ammonia	854	198	-	486	85	85	2,084	63%
Total Phosphorus	357	285	n/a[1]	n/a[1]	36	36	731	56%
CBOD	2,972	2,378	n/a[1]	n/a[1]	297	297	2,700	0.9%
SOD (gO2/m2/d)	0.7	n/a				0.07	2.0	69%

[1] Instream numeric water quality standard does not exist, explicit WLA not assigned for this parameter

Table 2-35: Dissolved Oxygen (SOD, CBOD, Ammonia, and Phosphorus) TMDL for Deer Creek Segment HBDC-02

Pollutant	LC (lbs/day)	LA (lbs/day)	WLA-Facilities (lbs/day)	WLA - MS4s (lbs/day)	MOS - 10% of LC (lbs/day)	RC - 10% of LC (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
Total Ammonia	76	37.8	-	23	7.6	7.6	95	28%
Total Phosphorus	52	41.6	n/a[1]	n/a[1]	5.2	5.2	61	23%
CBOD	404	324	n/a[1]	n/a[1]	40	40	367	0.9%
SOD (gO2/m2/d)	7	n/a				0.7	9	37%

[1] Instream numeric water quality standard does not exist, explicit WLA not assigned for this parameter

Table 2-36: Dissolved Oxygen (SOD, CBOD, Ammonia, and Phosphorus) TMDL for North Creek Segment HBDA-01

Pollutant	LC (lbs/day)	LA (lbs/day)	WLA-Facilities (lbs/day)	WLA - MS4s (lbs/day)	MOS - 10% of LC (lbs/day)	RC - 10% of LC (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
Total Ammonia	12	4.6	0.8	4.2	1.2	1.2	28	61%
Total Phosphorus	4.2	3.4	n/a[1]	n/a[1]	0.4	0.4	7.3	48%
CBOD	13	10.4	n/a[1]	n/a[1]	1.3	1.3	12	7%
SOD (gO2/m2/d)	0.9	n/a				0.09	1.1	26%

[1] Instream numeric water quality standard does not exist, explicit WLA not assigned for this parameter

2.3.6 Total Phosphorus and DO TMDLs for Sauk Trail Lake

A TMDL was developed for Sauk Trail Lake to determine the pounds of total phosphorus that can be allowed as input to the lake per day and still meet the applicable water quality standard. The lowest applicable water quality standard and TMDL target for total phosphorus is 0.05 mg/L. The allowable phosphorus loads that can be generated in the watershed and still maintain water quality standards were determined with the BATHTUB model discussed in **Section 1**.

DO concentration in lakes is typically a response variable to constituents, such as phosphorus or chlorophyll "a." Chlorophyll "a" indicates presence of excessive algal or aquatic plant growth. The correlation between average DO and chlorophyll "a" is typically an inverse relationship whereas the correlation between chlorophyll "a" and average total phosphorus is typically a direct relationship. These relationships would suggest that controlling phosphorus will decrease chlorophyll "a" concentrations, which will in turn increase DO concentrations. This hypothesis is supported by Wetzel who asserts that eutrophic (nutrient-rich) lakes have rapid rates of oxygen depletion (1983). Reducing total phosphorus is likely to reduce algal growth thus resulting in attainment of the DO standard. Therefore, no direct TMDL was developed for DO, but it is assumed that implementing a total phosphorus TMDL will solve any problems with low DO.

2.3.6.1 Loading Capacity

To calculate the LC, the predictive model discussed in Section 1 was used. After the model was shown to be reasonably predictive, the observed phosphorus concentration within the model was set to the Illinois lake water quality standard, 0.05 mg/L (50 µg/L). Then, the internal and external phosphorus loadings were reduced on a percentage basis, until the predicted phosphorus concentration matched the observed phosphorus concentration of 50 µg/L. This corresponded with a percent reduction of 63% for both internal and external phosphorus loading. The total allowable load of total phosphorus into Sauk Trail Lake calculated through BATHTUB is shown in **Table 2-37**.

Table 2-37: Estimated Phosphorus Loading Capacity for Sauk Trail Lake in the Thorn Creek Watershed

Waterbody	Segment	Loading Capacity (lbs/day)
Sauk Trail Lake	RHI	3.64

2.3.6.2 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions), explicit (expressed in the TMDL as a portion of the loadings), or a combination of both. The MOS developed for the Sauk Trail Lake TMDL is explicit. An explicit MOS of 10% was included to account for the lack of site-specific data available within this watershed. It is believed that the inclusion of an explicit MOS of 10% is adequate as the modeled values were in generally good agreement with the observed data.

2.3.6.3 Waste Load Allocation

The WLA for the phosphorus TMDL is applied to MS4s that exist in the Thorn Creek watershed, as described below. There are currently no individual NPDES permitted point sources in Sauk Trail Lake watershed.

MS4 Discharges

MS4 discharges represent runoff from municipal areas with separate stormwater sewer systems. MS4 discharges are regulated discharges and therefore, are allocated through WLAs, rather than

LAs. WLAs for MS4s in lakes are calculated in a similar way as those calculated for impaired stream segments. The total area within a municipality's boundaries that lies within the target lake's watershed was again determined using GIS analyses and geographic data for municipal boundaries from the U.S. Census Department (2000). The total municipal area within the watershed serves as an approximation of the total MS4 area in the watershed.

The proportion of total MS4 area to total watershed area was then calculated for the lake's sub-watershed. This proportion was then used to migrate loads from previously calculated LAs for overland runoff to WLAs for MS4 areas in each flow category. This process effectively transfers MS4 load allocations for overland runoff from non-regulated sources described as LAs to the WLA for regulated sources of contaminants. The total MS4 load allocations for phosphorus that are applied to the proportion of each municipality within the impaired lake's subbasin are shown in **Table 2-38.**

Table 2-38: Allocation Summary for MS4s in the Sauk Trail Lake Watershed

Source	NPDES ID	Municipal Area in Subbasin (acres)	Percent of Total Municipal Area in Subbasin	Total Phosphorus Allocation (lbs/day)
Chicago Heights	ILR400174	1.12	0.03%	0.001
Monee	ILG870335	407	9.6%	0.215
Park Forest	ILR400421	1,060	25.0%	0.559
South Chicago Heights	ILR400449	304	7.2%	0.160
University Park	ILR400250	2,471	58.2%	1.304
Total MS4		**4244**	**100.0%**	**2.240**

2.3.6.4 Reserve Capacity

An explicit RC was not included in the TMDL calculations for phosphorus due to the lack of point source loading of this constituent to Sauk Trail Lake. Non-point loads of phosphorus are also not expected to increase as a result of the population growth anticipated for the lake's watershed.

2.3.6.5 Load Allocation and TMDL Summary

A summary of the total phosphorus TMDL developed for Sauk Trail Lake is provided in **Table 2-39**. Required reductions in both internal and external total phosphorus loads are shown for the lake and reflect the reductions applied during the BATHTUB runs used to establish reduction criteria. While the overall load reduction for each segment is needed to meet the target, the relative proportion of the load reduction coming from internal or external sources can be modified and still result in compliance. Potential means of reducing both internal and external phosphorus loads into these waterbodies are discussed in detail in **Section 3** of this report.

Table 2-39: Total Phosphorus TMDL Summary for Sauk Trail Lake (RHI)

Segment	Loading Source	LC (lbs/day)	WLA (lbs/day)	LA (lbs/day)	MOS (10% of LC)	Current Load (lbs/day)	Reduction Needed (Percent)
RHI	Internal	0.05	-	0.045	0.005	0.13	63%
	External	3.59	2.24	0.99	0.36	9.68	63%
	Total	3.64	2.24	1.04	0.36	9.81	63%

2.4 LRS Allocation

Impairments based on narrative water quality standards are assessed through the development of LRSs. Watershed-specific numeric target values have been developed by Illinois EPA for LRS impairment parameters in the Thorn Creek watershed. The target values were used to develop target LCs for each impairment. The target LCs were then compared to current actual loads to develop percent reductions needed to meet the target value, as discussed in the following sections. The information provided by the development of these LRSs is intended to serve as a guide for future implementation activities to improve water quality throughout the Thorn Creek watershed.

2.4.1 Total Phosphorus LRS in Streams

Thorn Creek segments HBD-02, HBD-04, HBD-05, and HBD-06 and Deer Creek segments HBDC and HBDC-02 are each listed for impairment caused by elevated total phosphorus concentrations. As no numeric water quality standard exists for total phosphorus in streams in Illinois, a numeric target (0.226 mg/L) was developed by Illinois EPA for this watershed. A load duration curve was developed for each segment (see **Section 1**) to determine load reductions needed to meet the instream water quality target under varying flow scenarios. Due to the nature of the LRS program, load allocations for LRS analyses are voluntary measures and therefore, the distribution of loads and reductions between WLAs and LAs are not assessed for LRS parameters. No water quality data for segment HBDC (Deer Creek) exists; therefore, this segment was not evaluated here.

Table 2-40: Total Phosphorus Target Loading Capacity in Streams of the Thorn Creek Watershed

Estimated Mean Daily Flow (cfs)	Load Capacity (lbs/day)
1	1.219
5	6.095
10	12.19
50	60.95
100	121.9
500	609.5
1,000	1,219
1,500	1,828
2,000	2,438
5,000	6,095

2.4.1.1 Target Loading Capacity

The LC is the maximum amount of total phosphorus an impaired segment can receive and still meet the LRS target value for this watershed. The allowable phosphorus loads that may be generated in the watershed were determined using a range of estimated flow conditions and the numeric LRS target of 0.226 mg/L for total phosphorus, as discussed in **Section 1**. The total phosphorus LC for all impaired stream segments in the Thorn Creek watershed, according to flow, is presented in **Table 2-40**.

2.4.1.2 Percent Reductions and LRS Summaries for Total Phosphorus in Streams

Table 2-41 provides a summary of the LRSs and percent reductions from current conditions needed to meet the total phosphorus targets under various flow conditions in segment HBD-02. Based on the available data, instream concentrations in this reach exceed the LRS target value under all flow conditions. Target reductions in this segment range from 87 to 97 percent with the highest reduction needed under lower flow conditions.

Table 2-41: LRS Targets for Total Phosphorus in Thorn Creek HBD-02

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 – 10	540	4,123	87%
Moist	10 – 20	216	2,746	92%
	20 – 30	133	1,348	90%
	30 – 40	95	992	90%
Mid-Range	40 – 50	73	1,199	94%
Dry	50 – 60	59	828	93%
	60 – 70	49	1,202	96%
	70 – 80	41	985	96%
	80 – 90	35	1,223	97%
Low Flow	90 – 100	29	997	97%

Table 2-42 provides a summary of the LRS and percent reductions from current conditions needed to meet the total phosphorus targets under various flow conditions in Thorn Creek segment HBD-04. Instream concentrations in this reach exceed the LRS target value under all flow conditions. Target reductions in this segment range from 78 to 94 percent with the highest reduction needed again occurring during lower flow conditions.

Table 2-42: LRS Targets for Total Phosphorus in Thorn Creek HBD-04

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 – 10	567	2,562	78%
Moist	10 – 20	223	1,447	85%
	20 – 30	134	1,181	89%
	30 – 40	97	961	90%
Mid-Range	40 – 50	75	768	90%
Dry	50 – 60	63	1,020	94%
	60 – 70	53	526	90%
	70 – 80	44	710	94%
	80 – 90	36	603	94%
Low Flow	90 - 100	30	464	94%

A summary of the LRS and percent reductions from current conditions needed to meet the total phosphorus targets under various flow conditions in Thorn Creek segment HBD-05 is provided in **Table 2-43**. Instream concentrations in this reach exceeded the LRS target value under some flow conditions. Target reductions in this segment range from zero to 36 percent. The highest percent reduction was needed under dry conditions; however, some reduction was also needed during high/moist conditions.

Table 2-43: LRS Targets for Total Phosphorus in Thorn Creek HBD-05

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	130.1	140.1	7%
Moist	10 - 20	49.5	69.4	29%
	20 - 30	29.4	30.3	3%
	30 - 40	18.9	29.7	36%
Mid-Range	40 - 50	13.6	13.7	1%
Dry	50 - 60	9.2	5.7	None
	60 - 70	6.6	6.0	None
	70 - 80	4.0	3.9	None
	80 - 90	1.3	2.2	38%
Low Flow	90 - 100	0.5	0.5	None

The LRS and percent reductions from current conditions needed to meet the total phosphorus targets under various flow conditions in Thorn Creek segment HBD-06 are provided in **Table 2-44**. Instream concentrations in this reach again exceeded the LRS target value under all flow conditions. Target reductions in this segment range from 87 to 98 percent. The relative percent reductions needed in this segment are similar across flow ranges.

Table 2-44: LRS Targets for Total Phosphorus in Thorn Creek HBD-06

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	169	2,409	93%
Moist	10 - 20	82	651	87%
	20 - 30	58	901	94%
	30 - 40	48	1,017	95%
Mid-Range	40 - 50	40	1,084	96%
Dry	50 - 60	35	1,093	97%
	60 - 70	31	803	96%
	70 - 80	28	1,114	98%
	80 - 90	25	689	96%
Low Flow	90 - 100	21	380	94%

The LRS and percent reductions from current conditions needed to meet the total phosphorus targets under various flow conditions in Deer Creek segment HBDC-02 are provided in **Table 2-45**. Instream concentrations in this reach exceed the LRS target value under all flow conditions. Target reductions in this segment and range from 33 to 85 percent. The relative percent reductions needed in this segment appear to be somewhat greater during lower flow conditions.

Table 2-45: LRS Targets for Total Phosphorus in Deer Creek Segment HBDC-02

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	113	263	57%
Moist	10 - 20	46	127	64%
	20 - 30	27	66	60%
	30 - 40	18	27	33%
Mid-Range	40 - 50	13	27	51%
Dry	50 - 60	10	26	62%
	60 - 70	7	37	80%
	70 - 80	5	17	69%
	80 - 90	4	16	75%
Low Flow	90 - 100	2	16	85%

2.4.2 LRS for TSS and Sedimentation/Siltation in Stream Segments

Thorn Creek segment HBD-02 is listed for impairment caused by TSS. Likewise, North Creek segment HBDA-01 and Deer Creek segment HBDC-02 are listed for impairment caused by excess sedimentation/siltation, a similar measure of sediment loads in a waterbody. As no numeric water quality standard exists for either TSS or sedimentation and siltation in streams in Illinois, a numeric target of 72.7 mg/L of TSS was developed by Illinois EPA for use in assessing TSS impairments. Sedimentation/siltation impairments in the Thorn Creek watershed are assessed using an LRS target value for a surrogate parameter, NVSS, of 61.6 mg/L. No TSS data exists along segment HBD-02; therefore, a load duration curve with target load capacities was developed, but no actual loads or percent reductions were included. Load duration curves were developed (see **Section 1**) for segments HBDA-01 and HBDC-02 to determine load reductions for NVSS needed to meet the instream water quality target under a full range of flow scenarios.

TSS is a measurement of the sediment and organic material that inhibits natural light from penetrating the surface water column. Excessive sediment and organic material within the water column can negatively impact fish and macroinvertebrates within the ecosystem. Excess sediment and organic material may create turbid conditions within the water column and may increase the costs of treating surface waters used for drinking water or other industrial purposes (ex. food processing). Excessive sediment can reduce spawning and rearing areas for certain fish species. Excess suspended sediment can clog the gills of fish, stress certain sensitive species by abrading their tissue, and thus reduce fish health. When in suspension, sediment can limit visibility and light penetration, which may impair foraging and predation activities by certain species.

Excessive fine sediment also may degrade aquatic habitats by altering natural flow conditions in stream environments and adding organic materials to the water column. The potential addition of fine organic materials may lead to nuisance algal blooms that may prevent a waterbody from supporting aquatic life, aesthetic, and recreation uses. Algal decomposition depletes oxygen levels, which stresses benthic macroinvertebrates and fish. Excess algae can shade the water column and limit the distribution of aquatic vegetation. Established aquatic vegetation stabilizes bottom sediments and provides important habitat areas for healthy macroinvertebrates and fish communities.

2.4.2.1 Target Loading Capacity

The LC is the maximum TSS or NVSS load the impaired waters can receive and still meet the LRS target concentrations for TSS or sedimentation/siltation in this watershed. The allowable loads that may be generated in the watershed were determined using a range of estimated flow conditions and the numeric LRS targets of 72.7 mg/L for TSS and 61.6 mg/L of NVSS for sedimentation/siltation impairments, as discussed in **Section 1**. The TSS and NVSS LCs according to flow are presented in **Table 2-46**.

Table 2-46: TSS and Sedimentation/Siltation Loading Capacity as NVSS in Streams of the Thorn Creek Watershed

Estimated Mean Daily Flow (cfs)	TSS Target LC (lbs/day of TSS)	Sedimentation and Siltation Target LC (lbs/day of NVSS)
1	392	332
5	1,961	1,661
10	3,921	3,323
50	19,606	16,613
100	39,213	33,226
500	196,064	166,128
1,000	392,127	332,256
1,500	588,191	498,384
2,000	784,254	664,513
5,000	1,960,636	1,661,282

2.4.2.2 Percent Reduction and LRS Summary for TSS and Sedimentation/Siltation in Streams

Table 2-47provides a summary of the LRS and TSS target LC under various flow conditions encountered from 2000 to 2016 in Thorn Creek segment HBD-02. **Tables 2-48** and **2-49** provide summaries of the LRS and percent reductions of NVSS from current conditions needed to meet the sedimentation/siltation targets under various flow conditions in North Creek segment HBDA-01 and Deer Creek segment HBDC-02.

A detailed search for TSS data collected on Thorn Creek segment HBD-02 was conducted but no data were found. As a result, the percent reduction in NVSS required to meet the LRS target value could not be calculated. Future data collection and further analysis is recommended. If the impairment is not confirmed, delisting is recommended. Implementation strategies to reduce erosion and total suspended solids in the future are presented in **Section 3**. **Table 2-46** below shows the target LC for TSS for Thorn Creek segment HBD-02.

Table 2-47: LRS Targets for TSS in Thorn Creek HBD-02

Zone	Flow Exceedance Range (%)	Target LC (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 – 10	186,674	N/A	N/A
Moist	10 – 20	74,513	N/A	N/A
	20 – 30	44,315	N/A	N/A
	30 – 40	31,766	N/A	N/A
Mid-Range	40 – 50	25,099	N/A	N/A
Dry	50 - 60	20,393	N/A	N/A
	60 - 70	17,256	N/A	N/A
	70 - 80	14,118	N/A	N/A
	80 - 90	11,765	N/A	N/A
Low Flow	90 - 100	9,412	N/A	N/A

Table 2-48 provides a summary of the LRS and percent reductions from current conditions needed to meet the NVSS target developed for sedimentation and siltation impairments under various flow conditions in segment HBDA-01 of North Creek. Data is very limited – only eight water quality samples were available, and only one exceeded the LRS target value (under moist flow conditions). Target reduction for that one exceedance was 32%. It is not possible to identify a pattern of NVSS reduction targets with such limited data. Future additional data collection is recommended and implementation strategies to reduce erosion and sedimentation/siltation in the future are presented in **Section 3**.

Table 2-48: LRS Targets for Sedimentation/Siltation in North Creek HBDA-01

Zone	Flow Exceedance Range (%)	Target LC (lbs/day of NVSS)	Actual Load (lbs/day of NVSS)	Percent Reduction Needed (%)
High	0 - 10	38,802	N/A	N/A
Moist	10 - 20	22,353	32,775	32%
	20 - 30	14,340	4,190	None
	30 - 40	7,845	N/A	N/A
Mid-Range	40 - 50	4,892	N/A	N/A
Dry	50 - 60	2,868	3,256	None
	60 - 70	1,687	N/A	N/A
	70 - 80	1,097	326	None
	80 - 90	641	535	None
Low Flow	90 - 100	186	12	None

Table 2-49 provides a summary of the LRS and percent reductions from current conditions needed to meet the NVSS target developed for sedimentation/siltation impairments under various flow conditions in segment HBDC-02 of Deer Creek. Data is very limited – only two water quality samples were available, and only one exceeded the LRS target value (under dry flow conditions). It is not possible to identify a pattern of NVSS reduction targets with such limited data. Future additional data collection and further analysis is recommended. If the impairment is not confirmed, delisting is recommended. Implementation strategies to reduce erosion and sedimentation/siltation in the future are presented in **Section 3.**

Table 2-49: LRS Targets for Sedimentation/Siltation in Deer Creek HBDC-02

Zone	Flow Exceedance Range (%)	Target LC (lbs/day of NVSS)	Actual Load (lbs/day of NVSS)	Percent Reduction Needed (%)
High	0 - 10	20,966	N/A	N/A
Moist	10 - 20	9,149	N/A	N/A
	20 - 30	5,337	N/A	N/A
	30 - 40	4,193	N/A	N/A
Mid-Range	40 - 50	3,469	N/A	N/A
Dry	50 - 60	2,783	2,647	None
	60 - 70	1,811	1,671	N/A
	70 - 80	1,220	N/A	N/A
	80 - 90	953	N/A	N/A
Low Flow	90 - 100	648	N/A	N/A

2.4.3 LRS for TSS and Sedimentation/Siltation in Sauk Trail Lake

Sauk Trail Lake is listed for impairment caused by excess TSS and sedimentation/siltation. No numeric water quality standard exists for TSS or sedimentation/siltation in lakes or reservoirs in Illinois, so watershed-specific numeric targets of 72.7 mg/L of TSS and 61.6 mg/L for the sedimentation/siltation surrogate, NVSS, were developed by Illinois EPA to aid in assessment of these impairments. A detailed search for NVSS and volatile suspended solids data collected in Sauk Trail Lake was conducted but no data were found. As a result, the percent reduction in NVSS required to meet the LRS target value could not be calculated. Future data collection is recommended and implementation strategies to reduce erosion and sedimentation/siltation in the future are presented in **Section 3**. Determination of the reduction in TSS loads needed to meet the water quality targets was performed using a simplified spreadsheet calculation approach.

Excessive TSS in lakes can negatively impact fish and macroinvertebrates within the ecosystem. Excess sediment and organic material may create turbid conditions within the water column and may increase the costs of treating surface waters used for drinking water or other industrial purposes (ex. food processing). The potential addition of fine organic materials may lead to nuisance algal blooms that may prevent a lake from supporting aquatic life, aesthetic, and recreation uses. Algal decomposition depletes oxygen levels which may further stress benthic macroinvertebrates and fish.

The spreadsheet approach incorporates the available TSS data for Sauk Trail Lake and estimates of the average daily overland and tributary flow from the watershed to produce an estimate of the current average daily TSS load into the lake. The current load is then compared to the maximum daily load possible without exceeding the watershed-specific TSS target concentration value, to calculate the overall percent reduction in daily TSS load into the lake necessary to meet the target value.

A summary of percent reduction in TSS necessary to meet the target values in Sauk Trail Lake is presented in **Table 2-50**. An overall reduction in TSS loads of approximately 6.5 percent is necessary to meet the target value in Sauk Trail Lake.

Table 2-50: LRS Summary for TSS in Sauk Trail Lake (RHI)

Segment	Target Concentration (mg/L)	Existing Concentration (mg/L) [1]	Average Overland and Tributary Flow (cfs)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
RHI	72.7	77.4	12.7	4,996	5,319	6.5%

[1] Existing Concentration was calculated using the 90th percentile of observed TSS concentrations in a given location (USEPA 2007)

Section 3

Implementation Plan for the Thorn Creek Watershed

3.1 Implementation Overview

The goal of this watershed plan is to identify Best Management Practices (BMPs) that can be implemented in the Thorn Creek watershed that will provide reasonable assurance that impaired waters in the watershed will meet water quality criteria developed to ensure waterbodies are able to support their designated uses.

The USEPA has identified nine minimum elements that a watershed plan for impaired waters is required to include. A watershed plan is required to:

1. Identify causes and sources of pollution which will need to be controlled to achieve pollutant load reduction requirements estimated within the watershed plan (See Section 2.2).
2. Estimate pollutant load reductions expected as a result of implementation of the management measures described in #3 below (See Section 2.3).
3. Describe the nonpoint source management measures that will need to be implemented in order to achieve the load reduction estimates and identify the critical areas where measures need to be implemented for maximum effectiveness (See Section 3.3).
4. Identify the potential sources driving implementation of the prescribed management measures needed for project success; then determine the technical assistance needed for implementation and quantify its associated costs (See Section 3.10).
5. Include a public information/education component designed to change social behavior; then identify the indicators for success of this component (See Section 3.11).
6. Develop an implementation schedule for the plan (See Table 3-9).
7. Develop a description of interim, measurable milestones; then identify what a successful milestone looks like (See Section 3.15).
8. Identify indicators that can be used to determine whether pollutant loading reductions are being achieved over time (See Section 3.15).
9. Include the monitoring components needed to evaluate the effectiveness of the implementation efforts over time (See Section 3.15).

3.2 Adaptive Management

An adaptive management, or phased approach, is recommended for the implementation of management practices designed to meet the TMDLs and LRSs developed for the Thorn Creek watershed. Adaptive management is a process for continually improving management policies and practices by learning from the in-progress results of the operational programs. Because it is driven by real-world results, adaptive management complies with the USEPA guidelines described in **Section 3.1**. Some of the defining characteristics of adaptive management include:

- Acknowledgement of uncertainty about what policy or practice is "best" for the particular management issue
- Thoughtful selection of the policies or practices to be applied to each management issue during the assessment and design stages
- Careful implementation of a plan of action designed to identify the critical knowledge needed but not available during this adaptive management phase, and to establish this missing information
- Monitoring of key response indicators
- Analysis of the management outcomes in consideration of the original objectives and incorporation of the results into future decisions (British Columbia Ministry of Forests 2000)

Implementation actions, point source controls, management measures, and/or Best Management Practices (BMPs) are used to control the generation or distribution of pollutants within a watershed. BMPs are either structural; such as wetlands, filtration basins, or filter strips; or managerial, such as land use management, effective street sweeping programs, lawn fertilizer restrictions, and public outreach or education. Both structural and managerial BMPs require effective management and maintenance to be successful in reducing pollutant loading to water resources (Osmond et al. 1995).

It is typically most effective to install a combination of point source controls and BMPs, or a BMP system. A BMP system is a combination of two or more individual BMPs that are used to control pollutants from a single critical source. If the watershed has more than one identified pollutant, but the transport mechanism is the same, then a BMP system that establishes controls for the transport mechanism can be employed (Osmond et al. 1995).

To assist in development of an adaptive management program; implementation actions, management measures, available assistance programs, and recommended continued monitoring are all discussed throughout the remainder of this section. The point source controls noted below are generally required, and are typically already being implemented, although some permit modifications may be appropriate. The nonpoint source BMPs are entirely voluntary based on stakeholder and landowner preferences.

3.3 BMP Recommendations for Reducing TSS and Sedimentation/Siltation in Streams

The following stream segments are listed as impaired for TSS and/or sedimentation/siltation: Thorn Creek HBD-02, North Creek HBDA-01, and Deer Creek HBDC-02. The watershed-specific LRS target values for TSS and sedimentation/siltation within the Thorn Creek watershed are 72.7 mg/L of TSS and 61.6 mg/L of NVSS. As discussed in **Section 2.4.2**, the segments impaired for TSS or sedimentation/siltation either had little or no data available regarding these pollutants; however, since they are listed as impaired, some management strategies are needed. **Figure 2-4** in the AECOM Stage 1 report for the Thorn Creek watershed (AECOM 2011) shows the land around the HBD-02 segment to be primarily urban and forested. The figure also shows the lands around the HBDA-01 and HBDC-02 segments to consist of urban, forested, and agricultural areas, with some of the agricultural lands immediately adjacent to portions of the impaired stream segments. Therefore, urban and agricultural BMPs are appropriate for different areas of the stream sub-watersheds.

Nonpoint source runoff from both urban and agricultural areas, decreased infiltration associated with the prevalence of impervious surfaces, and increased overland flow are the main contributors to high sediment loads in the Thorn Creek watershed. Most modern developments route runoff from impervious surfaces directly into storm sewers or paved channels which effectively convey the pollutants, including sediments and suspended solids, into receiving waterbodies with little to no opportunity for infiltration or filtering. The storm sewers and lined channels then convey the runoff water downstream at a much faster rate than would normally occur in a natural, non-urbanized, setting. The increased flow rate leads to several issues including stream channel erosion and/or downcutting of the channel, both of which contribute to sedimentation/siltation and suspended solid loads. Alterations to natural storage and conveyance functions (e.g., stream channel modification) can also result in increased flow velocities and volumes subsequently causing stream channel erosion and increased flooding.

In addition to flow and conveyance concerns, building and road construction activity in and adjacent to waterbodies and wetlands create both short-term and long-term effects on water quality. Although erosion on construction sites often affects only a relatively small acreage of land in a watershed, it is a major source of sediment because the potential for erosion on highly disturbed land is commonly 100 times greater than on agricultural land (Brady and Weil 1999). The primary short-term effect is erosion in the denuded areas, those lacking vegetation, with potential deposition of sediment in nearby waterbodies. The long-term effects of urban development upon waterbodies and wetlands primarily result in the elimination of vegetation and other natural materials. The typical consequences of these alterations include reduced shading and a resultant increase in water temperature, reduced capacity for pollutant filtering, and increased stream instability and erosion.

Given these factors, nonpoint source controls designed to control erosion sources and/or to reduce TSS and NVSS loads stemming from overland flows in urban areas (discussed below) have been shown to reduce the TSS and sedimentation/siltation issues present in streams and lakes/reservoirs as well as provide a secondary benefit of reducing other contaminants, such as total phosphorus, that may be entering waterways via erosive processes. The BMPs discussed below are applicable to TSS and/or sedimentation/siltation impairments within the listed watersheds, and many of the BMPs may be used in both urban and agricultural settings.

Urban BMPs:

- Grass Filter strips
- Urban Reforestation/Forested Riparian Buffer Restoration
- Wetlands
- Stormwater Retention Basins (dry and wet ponds)
- Vegetated Swales
- Permeable Pavement
- Sand Filters
- Compost Blankets, Filter Berms, and Filter Socks
- Stormwater Reduction Techniques
- Bio-Retention Cells
- Streambank Stabilization and Erosion Control
- Street Sweeping

Agricultural BMPs:

- Grass Filter Strips
- Wetlands
- Compost Blankets, Filter Berms, and Filter Socks
- Streambank Stabilization and Erosion Control
- Conservation Tillage Practices

Grass Filter Strips: Filter strips are applicable to both rural and urban settings. Filter strips are vegetated areas of land planted along waterways (typically with grading efforts designed to reduce inflow rates) that are used to intercept runoff before it can enter a waterbody. The vegetation in the filter strip slows and filters runoff thereby serving as a control to reduce both pollutant loads from runoff and sedimentation to the impaired waterbody. Filter strips also provide bank stabilization thereby decreasing erosion and re-sedimentation. Grass filter strips have been shown to

Schematic of a filter strip and illustration of its benefits (USEPA 2017).

remove as much as 65 percent of sediment and 75 percent of total phosphorus loads from runoff (USEPA 2003). For agricultural areas, the Illinois Natural Resources Conservation Service (NRCS) Conservation Practice Standard 393 (June 2003) describes filter strip requirements based on land slope; the requirements are designed to achieve a minimum flow through time of 15 to 30 minutes at a one-half inch depth. **Table 3-1** provides a summary of the guidance for filter strip width, or flow length, as a function of slope (NRCS 2003). For more urbanized areas, the NRCS document *Urban Soil Erosion and Sedimentation Control* (NRCS 2008), suggests that filter strips are most effective in filtering runoff when slopes are less than 5%, but will function with a maximum slope of up to 15%.

Table 3-1: Filter Strip Flow Lengths Based on Land Slope

Percent Slope	0.5%	1.0%	2.0%	3.0%	4.0%	5.0% or greater
Minimum (feet)	36	54	72	90	108	117
Maximum (feet)	72	108	144	180	216	234

GIS land use data were used to provide an estimate of acreage within the Thorn Creek watershed where filter strips could be installed. In conjunction with the available land use, topography, and soil information discussed in the Stage 1 report, mapping software was used to identify potential buffer areas for impaired stream segments to an appropriate and reasonable width, described in **Table 3-1** above, to determine the total area found in each subbasin. Due to the diversity of soil types and slopes found throughout the watershed, the appropriate buffer widths estimated in GIS were based on the average slope of land within the maximum buffer areas of each impaired segment. These average slopes were then used to calculate approximate buffer distances based on the NRCS guidance using Table 3-1.

Not all land use types within the buffer areas are candidates for conversion to buffer strips. Existing forests and wetlands already function as filter strips or riparian buffers and conversion of developed residential or commercial lands is often infeasible. Because the primary land use within the buffer zones is urban, the greatest benefit to water quality may be installation of filter strips where there are semi-developed pervious land areas, e.g., parks or open areas within the stream buffers. Therefore, GIS software was used to calculate the approximate acreage of all non-forested lands within the appropriate buffer area for each impaired stream segment and its tributaries. These calculated buffer areas and acreage of convertible land within the buffer distances for each impaired stream segment and its tributaries are provided in **Table 3-2**. These data represent an approximation of the maximum acreage of land potentially available for conversion to filter strips along the mainstem of the impaired streams. More detailed assessment of a given property is necessary to determine the exact size and extent of convertible lands likely to provide the greatest benefit to instream water quality following conversion to filter strips.

There are approximately 992 total acres within the various buffer distances of impaired stream segments, an estimated 442 acres of which are not currently forest, wetland, or undeveloped grassland and where filter strips could be installed to benefit water quality. Much of the remaining land is currently low and medium density developed land which will need to be evaluated on a parcel-by-parcel basis to determine the feasibility of potentially installing this type of BMP. Landowners or managers should be encouraged to evaluate their land adjacent to impaired streams and their tributaries to determine the practicality of installing or extending filter strips to achieve effective flow lengths as described in the NRCS guidance provided in **Table 3-1**. Figures depicting the buffered areas and/or agricultural and urban lands suitable for conversion to filter strips in each subbasin are provided as **Figures 3-1** through **3-3**. Note that the land areas shown in red are unsuitable for conversion to filter strips. Table 3-2 Average Slopes, Filter Strip Flow Length, Total Buffer Area, and Area of Land within Buffers Potentially Suitable for Conversion to Filter Strips, by Stream Segment

Table 3-2: Average Slopes, Filter Strip Flow Length, Total Buffer Area, and Area of Land within Buffers Potentially Suitable for Conversion to Filter Strips, by Stream Segment.

Stream Name	**Segment ID**	**Average Slope Adjacent to Streams** (%)	**Filter Strip Flow Length** (feet)	**Total Area in Buffer** (Acres)	**Potentially Convertible Land in Buffer** (Acres)
Thorn Creek	HBD-02	5	234	218.65	45.73
North Creek	HBDA-01	2	144	430.69	231.74
Deer Creek	HBDC-02	2	144	342.25	164.44

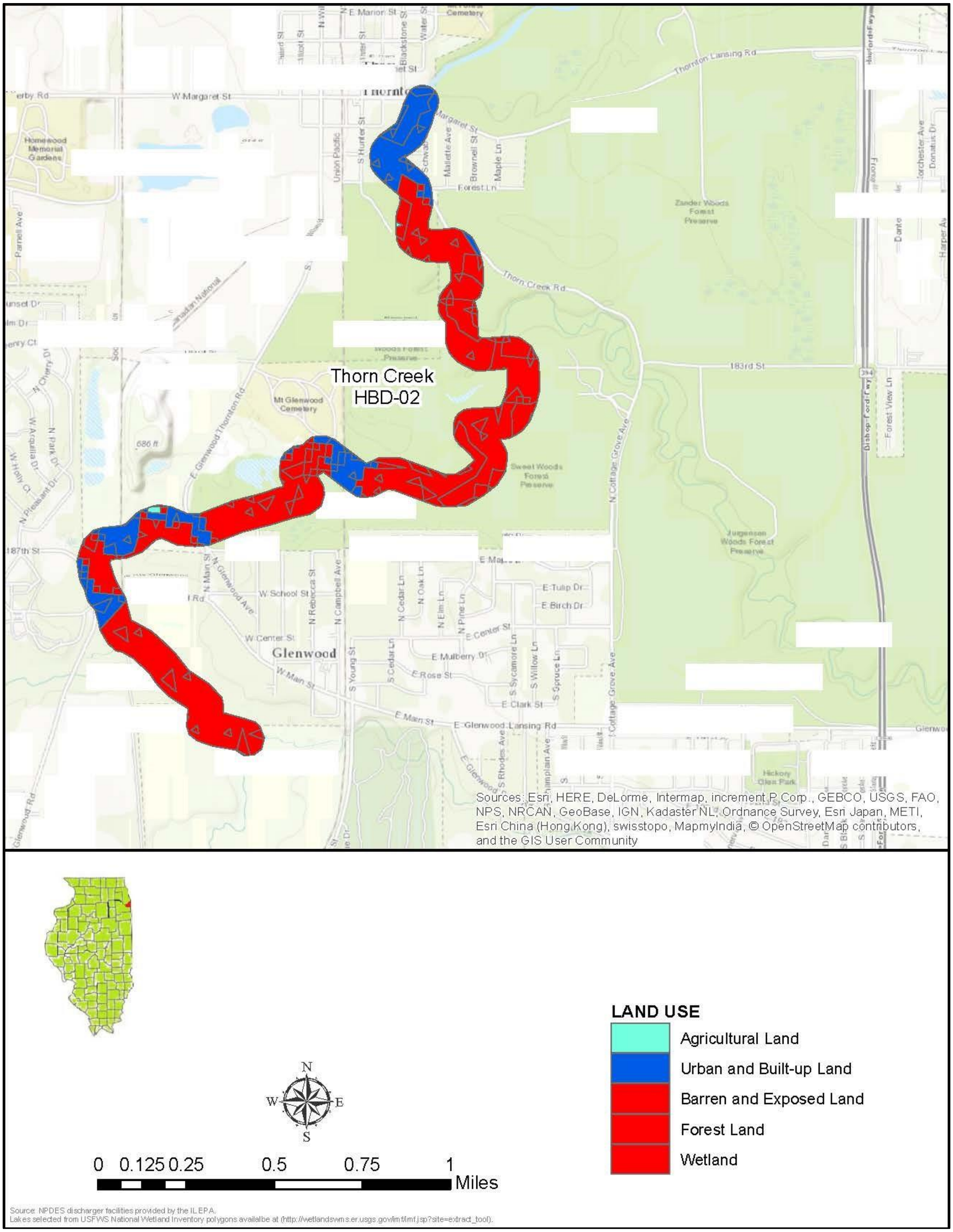


Figure 3-1: Thorn Creek Segment HBD-02 Buffer Land Uses Suitable for Conversion to Filter Strips

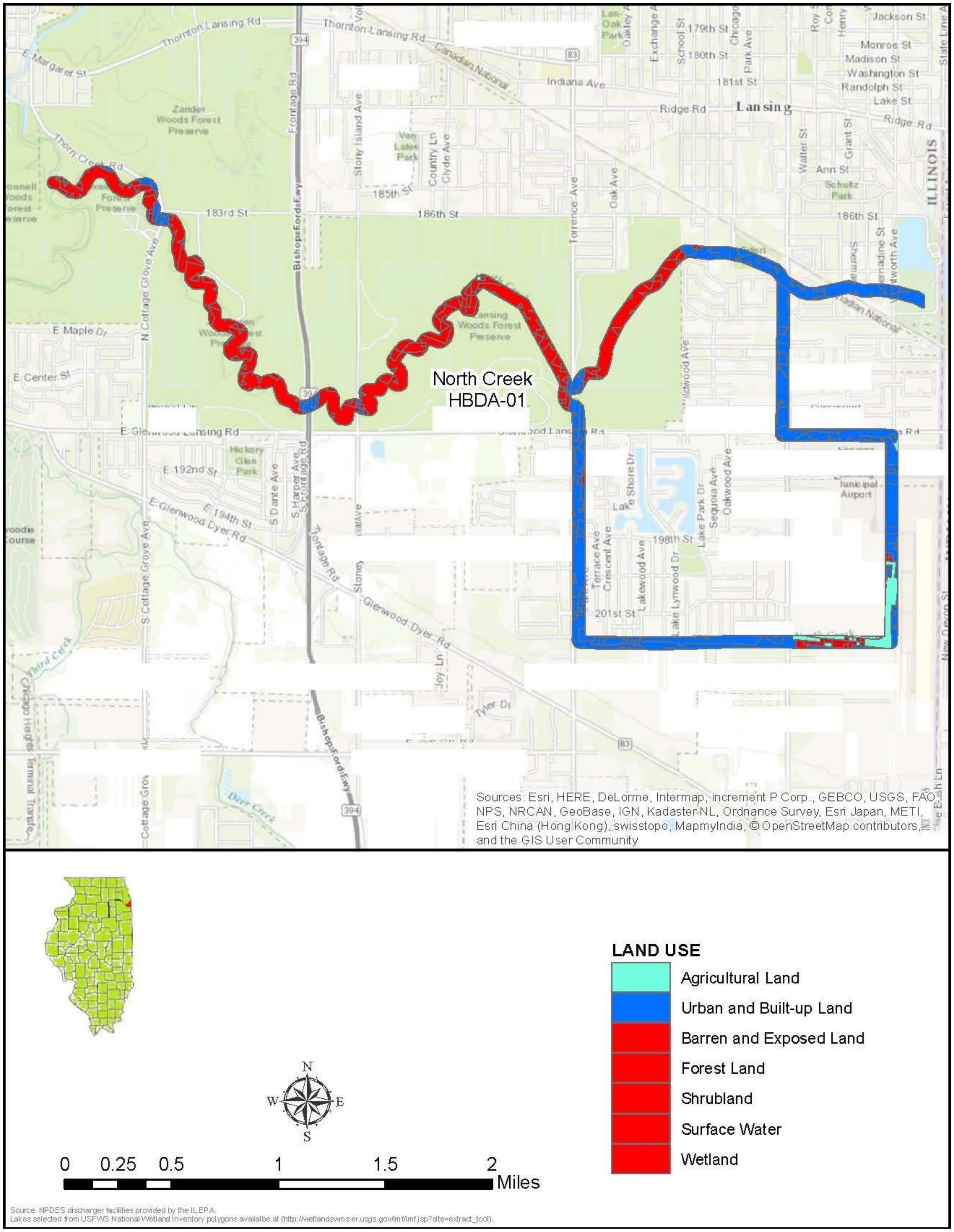


Figure 3-2: North Creek Segment HBDA-01 Buffer Land Uses Suitable for Conversion to Filter Strips

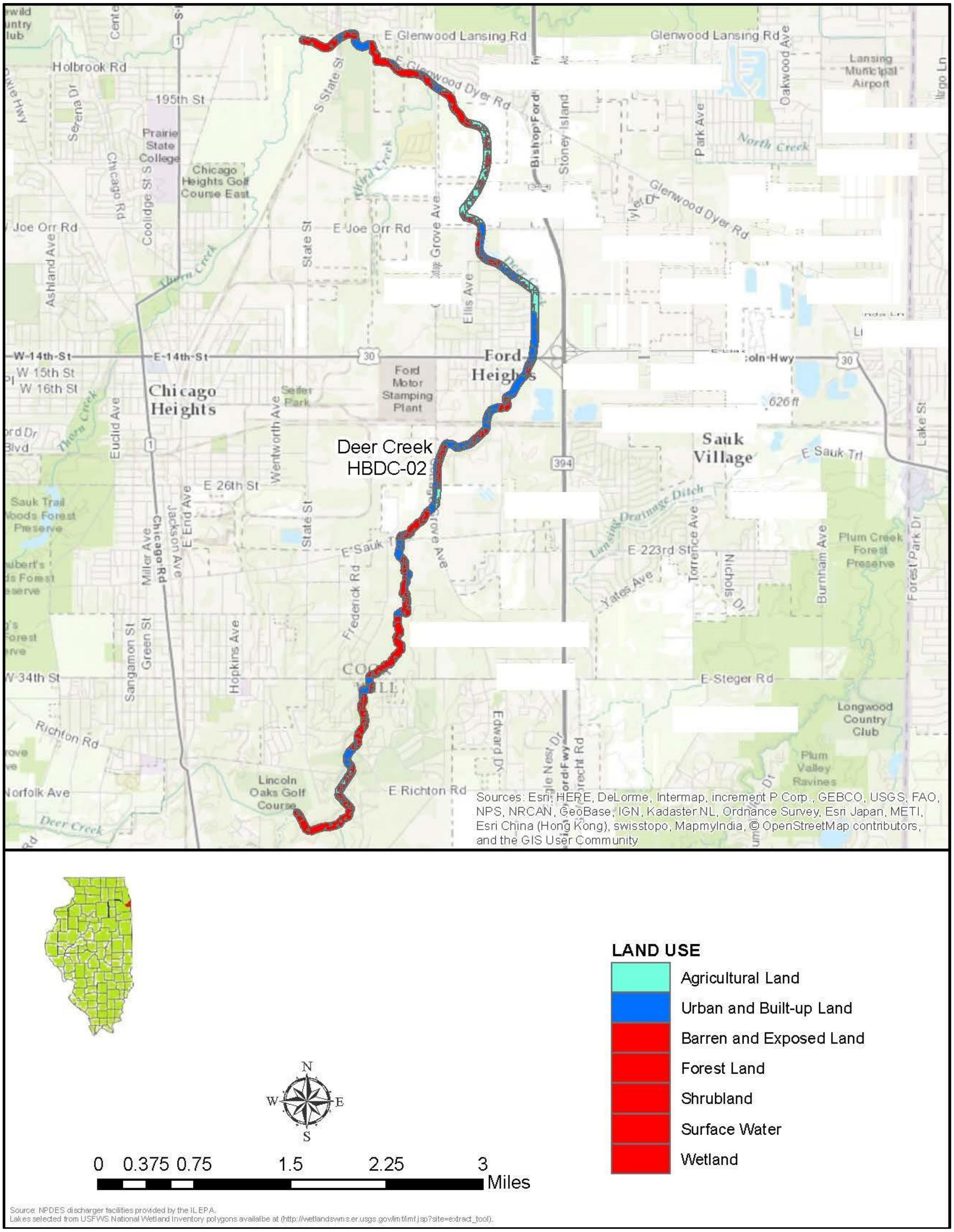
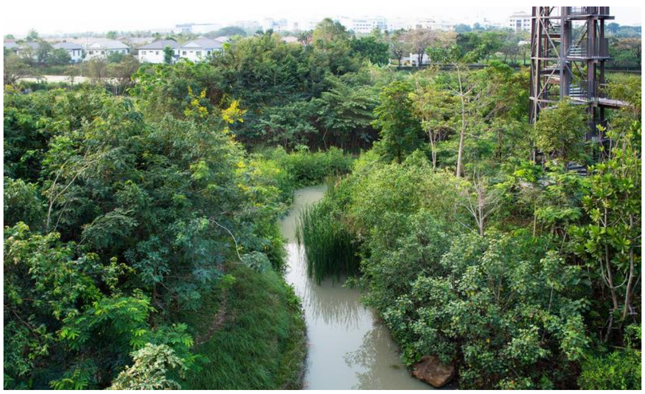


Figure 3-3: Deer Creek Segment HBDC-02 Buffer Land Uses Suitable for Conversion to Filter Strips

Urban Reforestation/Forested Riparian Buffer Restoration: Riparian buffers are also applicable to both rural and urban settings. Urban reforestation is the practice of planning and planting large areas of trees to increase the urban canopy and decrease impervious area. Riparian buffers are vegetated areas of land used to intercept runoff before it can enter a waterbody. The buffers slow and filter runoff thereby serving as controls to reduce both pollutant loads from runoff and sedimentation to the impaired waterbody. Maintaining and/or restoring riparian buffers with trees helps to filter pollutants out of runoff from roads, parking lots, and other paved areas. The trees provide shade to moderate soil and stream temperatures, which helps maintain healthy dissolved oxygen levels for aquatic life. Additionally, the rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion. Due to the increase in stormwater runoff volume and peak rates of runoff associated with urban development, stream channels are subject to greater erosional forces during stormflow events. Preserving natural vegetation along stream channels therefore minimizes the potential for water quality and habitat degradation due to streambank erosion as well as that additional pollutant or sediment load entering the stream.



*Forested riparian buffer (D*Hub 2016)*

The USEPA (2003) reports phosphorus removal rates of approximately 25 to 30 percent for 30 foot wide buffers and 70 to 80 percent for 60 to 90 foot wide buffers. Riparian corridors can typically treat a maximum of 300 feet of adjacent land before runoff forms small channels that short circuit treatment. Land use data for the Thorn Creek watershed were clipped to 25 feet buffer zones created around the impaired stream segments. Existing grassland, forest, and agricultural areas within the 25-foot buffer zones are shown in **Table 3-3** by segment. Landowners should assess parcels adjacent to the stream channels and maintain or improve existing riparian areas or potentially convert cultivated lands.

Table 3-3: Total Area and Area of Grassland, Forest, and Agricultural Land within 25-Foot Buffer, by Stream Segment

Stream Name	**Segment ID**	**Area in 25 ft Buffer** (Acres)	**Grassland in 25 ft Buffer** (Acres)	**Forest in 25 ft Buffer** (Acres)	**Agricultural Land in 25 ft Buffer** (Acres)
Thorn Creek	HBD-02	31.02	0	8.04	0
North Creek	HBDA-01	98.44	0.33	10.81	3.80
Deer Creek	HBDC-02	77.51	0.34	20.56	8.23

Implementation of an urban reforestation/riparian buffer restoration program requires a coordinated effort and sites should be prioritized for best results. The Northern Virginia BMP Handbook (1997) suggests the following considerations:

- Is the land already owned or planned for a public or semi-public use? In general, obtaining permission to replant a denuded buffer within an existing or planned public land use is more feasible than obtaining permission to replant on private land.

- Is the land slated for future development or infrastructure or has a riparian reforestation project already been planned for the site? It is best to consult with other agencies and organizations to be sure that there is no duplication of plans and to ensure that what is planted is not in an area slated for future development or the infrastructure that accompanies development. This includes communication with adjacent property owners and all utility companies (sewer, electric, cable, and phone).

- Does the site build upon already existing buffer areas to create a more robust forested buffer system? If a vegetated buffer is already in place, obtaining permission from a private landowner, or going through proper regulatory channels if the buffer is located on public land, may be more simple than attempting to convert a land use type to establish a forested buffer.

- Does the stream reach contain sensitive or endangered natural resources that will benefit from riparian reforestation? If a stream reach has been identified as being critical habitat to an endangered species, reforestation of that stream reach may be a priority.

- Will a buffer area reduce nonpoint source pollution from adjacent land uses or will adjacent land uses serve to degrade the buffer area? Buffer areas are effective at controlling pollutants in runoff only when the stormwater enters the system as slow, overland sheetflow. Buffer areas abutting large lot residential areas, or institutions with large areas of grass, can serve to significantly reduce nonpoint source pollution. However, buffers may not be useful, and may be damaged, if located near highly impervious land cover without adequate safeguards.

- Do the physical conditions of the site (such as degraded or under-cut streambanks or physical structures) allow the possibility of a vegetated buffer; and would additional site engineering be required? If so, would the cost, in terms of money and potential short term physical degradation, be worth the long term benefits?

Once program goals and objectives have been determined and sites have been prioritized, the Northern Virginia BMP Handbook also suggests the following to aid in the success of the program:

- Determine Planting Purposes – While the purpose of this suggested program is the reduction in nonpoint source pollution (particularly TSS through control of soil erosion, but also nutrients and oxygen demanding materials – to be discussed later in this section) other goals and objectives may coincide and be complimentary to nonpoint source pollution reduction. These other purposes may include: shade (temperature control and habitat); shelter from winds; screening of unsightly views; privacy buffers; boundaries for traffic control; lowering of carbon dioxide levels; reduced energy costs for buildings; specimen landscaping features and the removal of invasive plants; and potentially increased property values.

- Determine the General Planting Location Based on Objectives – Once the purpose has been established, where to plant should be considered to fulfil these purposes. As discussed above, urban reforestation/riparian buffer restoration should be focused in areas that are beneficial to the impaired stream segments in this watershed. Additional consideration in the placement of trees is the location of underground utilities. Location of underground utilities should be the first step in determining plant placement.

- Determine Ownership and Get Permission to Plant– If the planting is to be done on private property, the ownership of that property must be established and permission granted to go forth with the project. One must also receive permission to plant in public areas, whether it is a school, library, park, etc. Care should be taken not to plant in a public easement such as a future street right-of-way, sanitary sewer, or stormwater detention facility without proper permission. Trees may be removed or end up being damaged otherwise. Riparian buffer restoration work may require additional approvals. For instance, it is always wise to notify the Army Corps of Engineers about project activities. It is possible that the project will require a permit because the stream flow is being temporarily disturbed.

In addition to all of the above considerations, it is suggested that any program to reforest or restore riparian buffers should consult with a local arborist and/or area nurseries to determine the best trees for the available space, local climate, and soil types.

Wetlands: The use of wetlands as a structural control is applicable to sediment and nutrient reduction from urbanization in the Thorn Creek watershed. Even in urban settings, wetlands serve as an important buffer between terrestrial activities and aquatic environments. Existing wetlands should be maintained and additional wetlands could be constructed to treat loads from runoff at select locations where more focused runoff occurs and land use allows; e.g., at the downstream end of a drainage channel. Wetlands are effective BMPs for phosphorus and sediment control because they filter sediment and slow overland flow, thereby reducing soil erosion (NRCS 2014).

Wetlands (Oklahoma Conservation Commission 2015)

A properly designed and functioning wetland can provide very efficient treatment of pollutants, such as phosphorus, through nutrient cycling. Design of wetland systems is critical to the sustainable functionality of the system and should consider soils in the proposed location, hydraulic retention time, and space requirements. In general, soils classified as hydric are most suitable for wetland construction. The current extent of soils classified as hydric by the NRCS as well the current extent of existing U.S. Fish and Wildlife classified wetlands in the Thorn Creek watershed are shown in **Figure 3-4** and **Figure 3-5**. Areas near waterways that are not currently classified as wetlands but have hydric soils present are typically strong candidates for potential wetland construction. Existing wetland areas may also be candidates for reconstruction or enhancement to improve their nutrient uptake capacity. These data layers are developed on a large-scale and onsite soil investigation and wetland delineation is typically necessary for verification of the suitability of a given area for wetland construction.

Constructed wetlands, which comprise the second or third stage of a nonpoint source treatment system, can be very effective at improving water quality. Studies have shown that artificial wetlands designed and constructed specifically to remove pollutants from surface water runoff have removal rates of greater than 90 percent for suspended solids, up to 90 percent for total phosphorus, 20 to 80 percent of orthophosphate, and 10 to75 percent for nitrogen species (Johnson, Evans, and Bass 1996; Moore 1993; USEPA 2003; Kovosic et al. 2000). Although the removal rate for phosphorus is low in long-term studies, the rate can be improved if sheet flow is maintained to the wetland and vegetation and substrate are monitored to ensure the wetland is operating optimally. Sediment or vegetation removal may be necessary if the wetland removal efficiency is lessened over time (USEPA 2003). Guidelines for wetland design suggest a wetland to watershed ratio of 0.6 percent for nutrient and sediment removal from agricultural runoff.

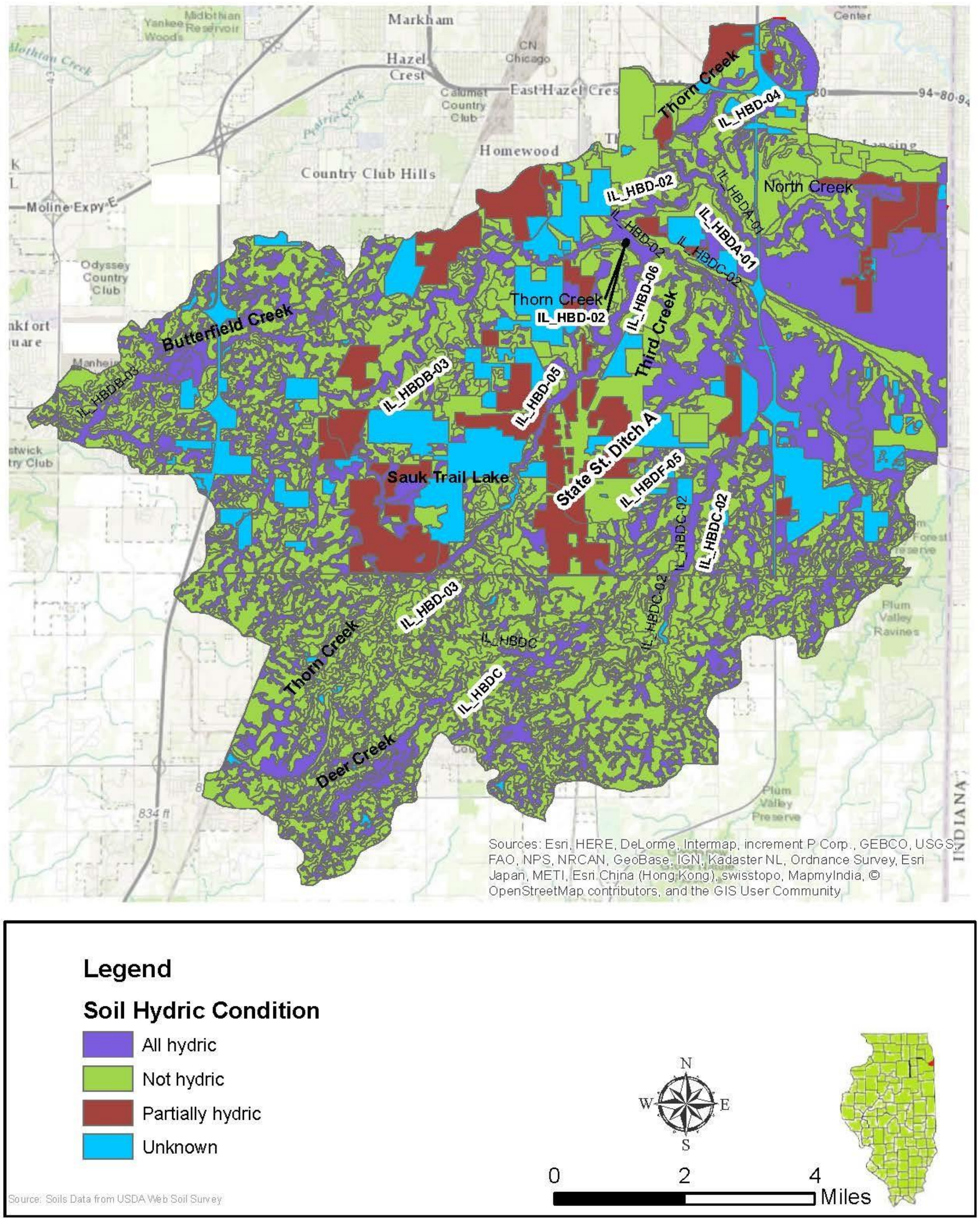


Figure 3-4: Thorn Creek Watershed Hydric Soil Conditions

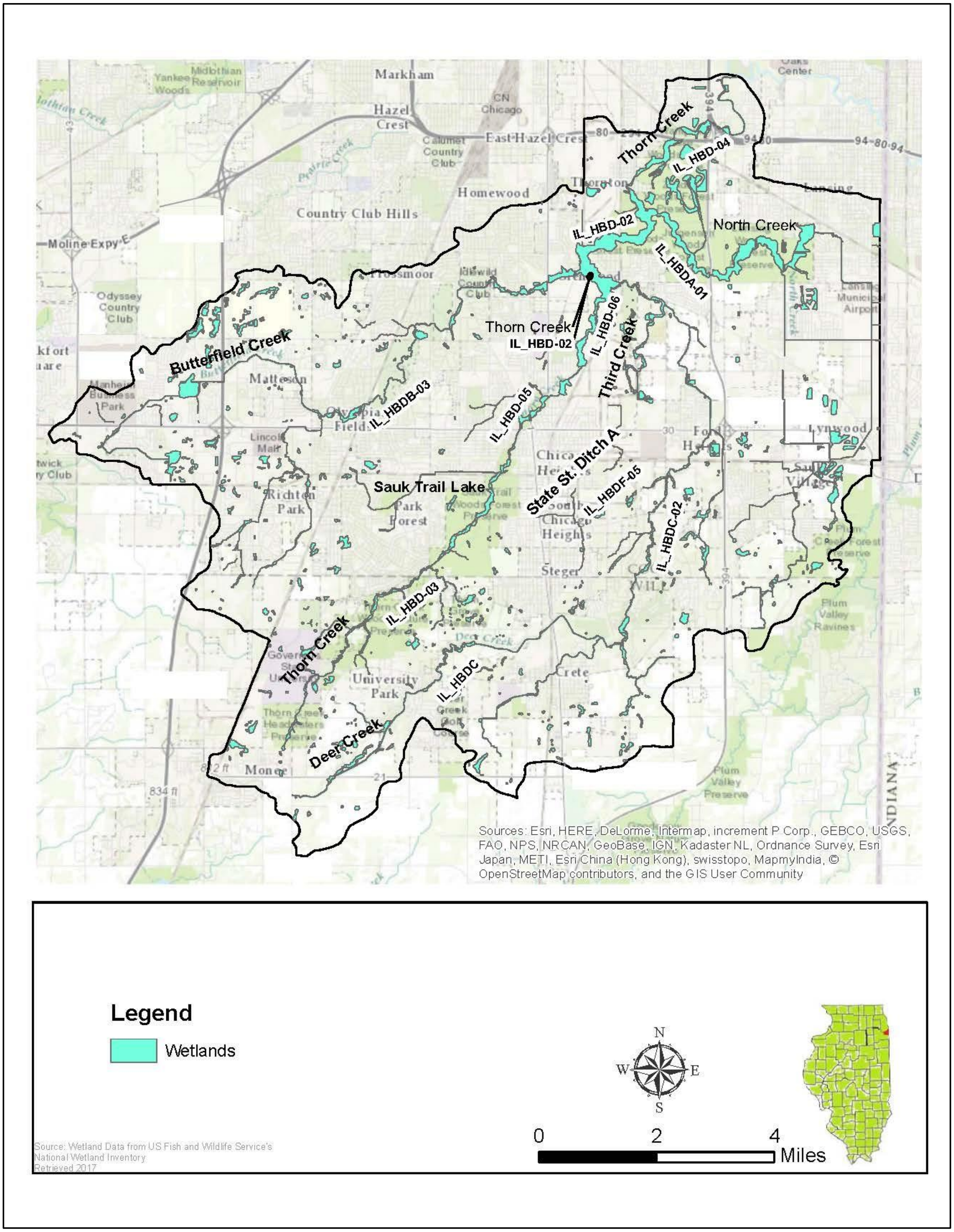


Figure 3-5: Thorn Creek Watershed Wetlands

Stormwater Retention Basins (Dry and/or Wet Ponds): Control basins and ponds ("dry" or "wet") may be used for flood control and treatment of stormwater. Both systems function to settle suspended sediments and other solids typically present in stormwater runoff.

Stormwater ponds are also called retention ponds or "wet" ponds and they hold back water similar to water behind a dam. The pond has a permanent pool of water that fluctuates in response to precipitation and runoff from the contributing areas. Maintaining a pool discourages resuspension and keeps deposited sediments at the bottom of the holding area. USEPA's 1993 Nationwide Urban Runoff Program indicated that up to two-thirds of the sediment, nutrients and trace metals can be removed via sedimentation within 24 hours, while two weeks are required to remove a significant amount of phosphorus. A wet detention basin must receive and retain enough water from rain, runoff, and groundwater to maintain a permanent pool in the deeper areas of the basin. Most sources recommend a minimum drainage area of 10 to 25 acres to sustain a constant inflow. Wet detention basins should be sized to treat the water quality volume and detain and release the 100-year event. The permeability of hydrologic soil groups "C" and "D" is suitable for a wet basin without modification. The side slopes of a wet detention basin should be no steeper than 5:1 above the normal water level (DuPage County 2008).

Stormwater retention basin (USEPA 2016a)

Dry ponds which may also be referred to as extended detention basins, detention ponds, and/or extended detention ponds are basins whose outlets are designed to detain the stormwater runoff from a water quality "storm" for some minimum duration (e.g., 24 hours) which allow sediment particles and associated pollutants to settle out. Unlike wet ponds, dry extended detention ponds do not have a permanent pool. However, dry extended detention ponds are often designed with small pools at the inlet and outlet of the pond, and can also be used to provide flood control by including additional detention storage above the extended detention level.

Although the Thorn Creek watershed is highly urbanized, both wet and dry ponds can be very useful stormwater retrofits with two primary applications as a retrofit design. In many communities, including the Chicago metropolitan area, detention basins have been designed for flood control in the past. It is possible to modify these basins to incorporate features that encourage water quality control, and/or channel protection. It is also possible to construct new dry extended detention ponds in open areas of a watershed to capture existing drainage, or create them above a road crossing or culvert.

In general, dry extended detention ponds should be used at sites with a minimum drainage area of 10 acres. On smaller sites, it may be difficult to provide channel or water quality control because the orifice diameter at the outlet becomes very small, and is thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale in pond construction. Dry ponds can be used on sites with slopes up to about 15% although the local slope needs to be relatively flat to maintain reasonably flat side slopes. While there is no minimum slope requirement, enough elevation drop is needed from the pond inlet to the pond outlet to ensure that flow can move through the system (Stormwater Manager's Resource Center 2016).

Vegetated Swales: Vegetated swales are an effective infiltration-based technique in an urban setting. These swales use an open channel designed to attenuate runoff. As runoff or stormwater discharge enters these channels, it is slowed by the vegetation; this subsequently reduces sediment suspension, promotes filtration through soil, and increases infiltration into groundwater. Pollutants are removed by settling and infiltration into soil and by biological uptake of nutrients. They also increase the time of retention within the watershed, further reducing peak flow rates. Grassed swales therefore provide the benefits of reducing peak flows and increasing pollutant removal, at low capital cost. Swales are particularly well suited for highways, roads, and parking lots because the channel designs are straight and can be easily incorporated into design schemes (Koski and Kinzelman 2010). Swales are not practicable in areas with flat grades, steep grades, or in wet or poorly drained soils, but are an excellent choice for many urban areas given the low land area requirements compared to many alternatives.

Vegetated swales (Dott Architecture 2010)

The swales can be used as a standalone option or as a conveyance mechanism to channel runoff to other retentive BMPs. Benefits of this BMP come from reductions in runoff volume and removal of nutrients, sediments, and heavy metals [TSS (86%), total phosphorous (34%), soluble phosphorous (38%), total nitrogen (84%), carbon (69%), and moderate reductions of heavy metals (cadmium 42%, copper 51%, lead 67%, and zinc 71%)] (Schueler and Holland 2000b).

Permeable Pavement: Permeable pavement removes waterborne pollutants from stormwater runoff and allows it to filter through the underlying soil. Permeable pavements functions similar to other infiltration measures. The pavement traps some particulate bound pollutants, but most of the runoff and pollutants are discharged to the groundwater, as there is usually little organic-rich soil beneath permeable pavements that trap the pollutants as in most other infiltration devices.

Permeable pavement (NCSWCD 2017)

A permeable pavement is constructed of a permeable asphalt or bituminous concrete surface with a 2.5 to 4 inch thickness that is placed over a highly permeable layer of crushed stone or gravel, 24 inches thick. A filter fabric can be placed beneath the gravel or stone layer to prevent movement of fines into the deeper layers, although many installations show clogging of the filter fabric, and most recent designs use rock filters and not filter fabrics. Runoff from the stone and gravel layers then infiltrates into the soil. If the infiltration rate is slow, perforated underdrain pipes can be placed in the stone layer to convey the water back to a surface waterway. The primary advantage of permeable pavement is that it can be put to dual use, allowing the mitigation of waterborne pollutants, while still allowing urban use of the land, i.e. driving. But, permeable pavements are not as durable as conventional pavements and generally have much lower vehicle load limits. Also, they are costlier than conventional pavements(Pitt and Narayanan 2016), and require regular street sweeping to maintain their ability to infiltrate water.

Sand Filters. Sand filters are also an infiltration-based technique that can be used for both sediment/TSS and pollutants. Water enters a settling basin to remove heavier sediments and is then directed to filter media composed of sand or an appropriate organic material. Sand filters are a good option for highly urban areas because they occupy little space, tend to be easier to retro-fit compared to other BMPs, and have few design restrictions. However, these types of structures can be high maintenance and costly to construct (USEPA 1999). Sand filters can effectively remove a large range of pollutants, including the following: fecal coliform from 51% to over excess of 99% (Schueler and Holland 2000a, Clary et al. 2008), TSS at an average of 87% (Schueler and Holland 2000b), total phosphorus at around 59%, and carbon at about 67%.

Sand filter (DEP 2017)

Compost Blankets, Filter Berms, and Filter Socks: Compost blankets, compost filter berms, and compost filter socks are BMPs employed to reduce surface runoff, particularly addressing the reduction of sediments and other suspended solids.

- Compost blanket: This is a layer of loosely applied composted material placed on soil in a disturbed area to reduce stormwater runoff and erosion. The material fills in small rills and voids to limit channelized flow, provides a more permeable surface to facilitate stormwater infiltration, and promotes revegetation. Seeds can be mixed into the compost before it is applied. Applying a compost blanket works well as a stormwater BMP because it a) retains a large volume of water, which aids in establishing vegetation growth within the blanket, b) acts as a cushion to absorb the impact energy of rainfall, which reduces erosion, c) stimulates microbial activity that increases the decomposition of organic matter, which increases nutrient availability and improves the soil structure, d) provides a suitable microclimate with the available nutrients for seed germination and plant growth, and e) removes pollutants such as heavy metals, nitrogen, phosphorus, fuels, grease, and oil from

Compost filter berm (UGA Extension 2012)

stormwater runoff, thus improving downstream water quality (USEPA 1998).

- Compost filter berm: A compost filter berm is a dike of compost or a compost product that is placed perpendicular to runoff to control erosion in disturbed areas and retain sediment. Compost berms can be placed at regular intervals to help reduce the formation of rill and gully erosion when a compost blanket is stabilizing a slope.

- Compost filter sock: A compost filter sock is a three-dimensional tubular sediment control and stormwater runoff filtration device typically used for perimeter control of sediment and soluble pollutants (such as phosphorus and petroleum hydrocarbons). They are effective when installed perpendicular to sheet or low concentrated flow. Compost filter socks trap sediment and soluble pollutants by filtering runoff water as it passes through the matrix of the sock and by allowing water to temporarily pond behind the sock, allowing deposition of suspended solids. Applications include: construction sites; site perimeters; above and below disturbed areas subject to sheet and rill erosion; above and below exposed and erodible slopes; along the toe of stream and channel banks; around area drains or inlets located in a 'sump'; and on or around areas where trenching of silt fence is difficult or impossible, such as on compacted soils, frozen or paved ground, or around sensitive trees where trenching of silt fence is not beneficial for tree survival or may unnecessarily disturb established vegetation.

Stormwater Reduction Techniques: Reducing the amount of stormwater entering receiving waterbodies via overland flow can help reduce the amount of sediment and pollutants concurrently carried into the waterbodies. Stormwater reduction techniques which may be implemented in urban settings include the following:

- Rain barrels: These are designed to catch water from downspouts and store it for non-potable uses such as gardening.

- Rain gardens are a type of bio-retention cell (which are described below)

- Green roofs: These are an engineering technique that uses vegetation on rooftops to reduce runoff, which in turn reduces the transport of sediment. In urban areas, green roofs can represent a large surface area, and may help retain as much as 87% of rainfall.

Bio-retention cells: Bio-retention cells, or rain gardens, are a low impact development technique in which vegetation and infiltration are used to hold and treat stormwater at the source of discharge. Properly used bio-retention cells can reduce runoff volumes, increase groundwater recharge, increase evapotranspiration, provide a lag time for discharged runoff, and reduce pollutants entering ground and surface waters (Hunt et al. 2008). The cells were initially designed to handle the runoff

Bio-retention cell (CU 2015)

from smaller sites, between one and three acres, but can be modified to fit inside a variety of sites.

Bio-retention cells are designed to decrease the volume of effluent as well as improve water quality through filtration, infiltration, adsorption, and bio-transformations. Typical designs consist of sloped grass buffer strips which convey water into an infiltration basin. The infiltration basin consists of a layer of highly permeable media, such as sand, which is covered by a layer of planting soil and mulch. The mulch layer is planted with fauna such as earthworms to keep soil pores open, increase transpiration, and potentially uptake pollutants. Depending on the soil infiltration rate of the site, an underlying drain can be added to remove excess water from the media. In bench studies of simulated bio-retention cells, fecal coliform reduction rates have been observed from 54 to 99.8% with an average decrease of 91.6% (Rusciano and Obropte 2007); copper, lead and zinc were removed in excess of 95%; and total phosphorus was removed at approximately 80% (Koski and Kinzelman 2010).

Streambank Stabilization/Erosion Control: Soil erosion is the process of moving soil particles or sediment by flowing water or wind. Additionally, eroding soil transports pollutants that can potentially degrade water quality. Three available approaches to potentially decrease nonpoint TSS, sedimentation/siltation, and/or pollutant source loads in an urban setting, as well as helping to stabilize eroding banks include the following:

- Stone Toe Protection: Non-erodible materials are used to protect the eroding banks of a stream. Meandering bends found in the watershed could potentially be stabilized by placing the hard armor only on the toe of the bank. Stone toe protection is most commonly implemented "using stone quarry stone that is sized to resist movement and is placed on the lower one third of the bank in a windrow fashion" (Kinney 2005).

- Rock Riffle Grade Control: Naturally stable stream systems typically have an alternating riffle-pool sequence that helps to dissipate stream energy. Riffle rock grade control places loose rock grade control structures at locations where natural riffles would occur to create and enhance the riffle-pool flow sequence of stable streams. By installing riffle rock in an incised channel, the riffles will raise the water surface elevation resulting in lower effective bank heights, which increases the bank stability by reducing the tractive force on the banks (Kinney 2005).

- Rock chutes: Rock chutes are riprap lined water conveyance structures used to move water down a slope in a non-erosive manner. The main purpose of a rock chute is to reduce channel flow velocity by dissipating energy and to provide a stable grade at the outlet to prevent erosion.

- Silt Fences: Silt fences are temporary fences used for sediment control. Silt fences are inexpensive and simple to implement, and function by trapping sediment behind the fence, rather than allowing it to continue into waterways.

- Gabions: Gabions are mesh cages filled with rocks, broken concrete, and sand and soil, and are sometimes used in the construction of retaining walls. Gabions provide extra support for erosion control structures, helping to minimize sediment transport into waterways.

Street Sweeping – Street sweeping is the practice of passing over an impervious surface, usually a street or a parking lot, with a vacuum or a rotating brush for the purpose of collecting and disposing of accumulated debris, litter, sand, and sediments. Street sweeping is widely practiced by urban and suburban governments for litter and dust control. In addition, many commercial establishments utilize street sweeping for aesthetic reasons.

For street sweeping to have a beneficial effect on water quality in urban areas, a schedule of frequent sweeping must be established. There are several types of street sweepers, some of which are more effective than others at removing certain types of nonpoint source pollution. Some examples of street sweeping devices include mechanical sweepers, vacuum assisted mechanical sweepers, regenerative cleaners, industrial type vacuum sweepers, hand sweepers, and street flushers, although vacuuming is ideal so that sediment will not simply be redeposited within the same land area. The physical removal of particulates and attached fine pollutant particles from the street surface will lessen the pollutant load transferred to receiving waters.

Street sweeper (Mill City Times 2016)

Studies have shown that there are certain times when street sweeping is very effective in improving water quality. In areas with defined wet and dry seasons, sweeping prior to the wet season is likely to be beneficial, and is highly effective at reducing chloride loads to streams. Other times when sweeping is beneficial are following snow melt and heavy leaf fall (Northern Virginia 1997). The current extent of street sweeping in the watershed, type of equipment used, and program schedules are currently unknown. Each local jurisdiction in the watershed should be encouraged to review their existing program and make adjustments, as needed, to include pollutant removal and water quality improvements program goals.

Conservation Tillage Practices: While most of the land around the impaired stream segments is urban, conservation tillage practices could help reduce sediment loads into the portions of the impaired segments adjacent to agricultural land by reducing erosion of soils. In conservation tillage, at least 30 percent of the soil surface retains cover by residue after planting. Crop residuals or living vegetation cover on the soil surface protects against soil detachment from water and wind erosion.

Conservation tillage practices are grouped into three types: no-till, ridge-till, and mulch-till. No one method is best for all fields; instead, the decision on the type of conservation tilling to be used should be based on factors such as the severity of the erosion problem, the soil type, crop rotation, and available equipment. No-till leaves the soil undisturbed from harvest to planting thus leaving a high percentage of surface covered by crop residues. No-till planting can be done successfully in chemically-killed sod, in crop residues from the previous year, or when double-cropping after a small grain. The planting is done in a narrow (usually 6 inches or less) seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers. A press-wheel follows to provide firm soil-seed contact. Herbicides are the primary method of weed control, although cultivation may be used for emergency weed control.

Ridge-till involves planting into a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. The ridges are rebuilt during cultivation and, except for nutrient injection, the soil is left undisturbed from harvest to planting. Ridge-till systems therefore leave residue on the surface between ridges so the degree of soil conservation depends on the amount of residue and the row direction. Planting on the contour and increased surface coverage greatly reduce soil loss. Ridge-till works best on nearly level, poorly drained soils. The ridges speed up drainage and soil warm-up. Cultivation controls weeds along with some herbicides.

Mulch-till uses chisel plows, field cultivators, disks, sweeps, or blades to till the soil before planting. The tillage does not invert the soil but leaves it rough and cloddy. Various chisel points or sweeps attached to the shanks affect the amount of residue cover left on the soil surface. The effectiveness of mulch-till systems in reducing erosion depends on surface roughness, amount of residue, and tillage direction. Fall chiseling should be done to a depth of 8-10 inches, and spring chiseling should be no deeper than 6 inches. Disking or other shallow tillage operations can be used in seed bed preparation. A standard, or tandem, disk does not till as deep and leaves more residue on the surface compared to heavy (offset) disks. Herbicides and/or cultivation controls weeds in a mulch-till system.

Conservation tillage practices can remove approximately 75 percent of the sediment and up to 45 percent of the dissolved and total phosphorus from runoff. Additionally, studies have found around 93 percent less erosion occurred from no-till acreage compared to acreage subject to moldboard plowing (USEPA 2003). Tillage practices, particularly adjacent to the HBDA-01 and HBDC-02 impaired segments should be assessed and possibly improved upon to reduce sediment loads.

3.4 BMP Recommendations for Reducing TSS and Sedimentation/Siltation in Sauk Trail Lake

It should be noted that Sauk Trail Lake (RHI) is scheduled to have its dam removed in 2021-2022, by the US Army Corp of Engineers. Since the lake was created by damming Thorn Creek, removing the dam should effectively eliminate Sauk Trail Lake. The dam removal will have a host of positive environmental impacts, including ecosystem restoration and correcting habitat damage. When the dam is removed, the TMDL for Sauk Trail Lake will no longer be relevant.

TSS and NVSS load reductions are needed for Sauk Trail Lake in order to meet the watershed-specific LRS target value. The percent reductions needed for TSS in Sauk Trail Lake are discussed in **Section 2.4.3**. Nonpoint source controls designed to reduce erosion and overland flow are expected to reduce TSS in lakes as well as provide a secondary benefit of reducing other contaminants such as total phosphorus that may be entering waterways via erosive processes. **Figure 2-4** in the AECOM Stage 1 report for the Thorn Creek watershed (AECOM 2011) shows the land around the lake to be primarily urban and forested. The BMPs discussed in **Section 3.3** are also applicable to TSS impairments within the lake.

A stormwater retention basin, **sand filtration basin**, and/or **bio-retention cell** could be constructed at the upstream end of the lake. **Filter strips**; **riparian buffers**; **vegetated swales**; **permeable pavement**; **compost blankets, berms, and socks**; and **stormwater reduction techniques** may also be employed in select areas to help control overland flow and the associated transport of sediment and pollutants.

For the **filter strips**, potential tributary and shoreline buffer areas were calculated using average slopes in the subbasin as described in **Section 3.3**. The average slopes, appropriate filter strip flow lengths, and calculated areas within the buffer distances for Sauk Trail Lake are provided in **Table 3-4**. The table also shows estimated acres of open land surrounding the lake and its tributaries where filter strips could potentially be installed. Landowners or managers should be encouraged to evaluate their land adjacent to the impaired lake to determine the practicality of installing or extending filter strips to achieve effective flow lengths as previously described. **Figure 3-6** depicts the buffered areas and open lands suitable for conversion to filter strips in the lake's subbasin.

Table 3-4: Average Slopes, Filter Strip Flow Length, Total Buffer Area, and Area of Land within Buffers Potentially Suitable for Conversion to Filter Strips, by Lake

Waterbody Name	**Segment ID**	**Average Slope** (%)	**Filter Strip Flow Length** (feet)	**Total Area in Buffer** (Acres)	**Potentially Convertible Land in Buffer** (Acres)
Sauk Trail Lake	RHI	11	234	51.6	4.87

For the **riparian buffers**, potential tributary and shoreline buffer areas were estimated as described in **Section 3.3** and are shown in **Table 3-5**. Landowners or managers should be encouraged to assess parcels adjacent to the impaired lake and maintain or improve existing riparian areas or potentially convert semi-developed lands.

Table 3-5: Total Area and Area of Grassland, Forest, and Agricultural Land within 25-Foot Buffer of Impaired Lake and its Major Tributaries

Stream Name	**Segment ID**	**Area in 25 ft Buffer** (Acres)	**Grassland in 25 ft Buffer** (Acres)	**Forest in 25 ft Buffer** (Acres)	**Agricultural Land in 25 ft Buffer** (Acres)
Sauk Trail Lake	RHI	4.96	0.01	1.82	0

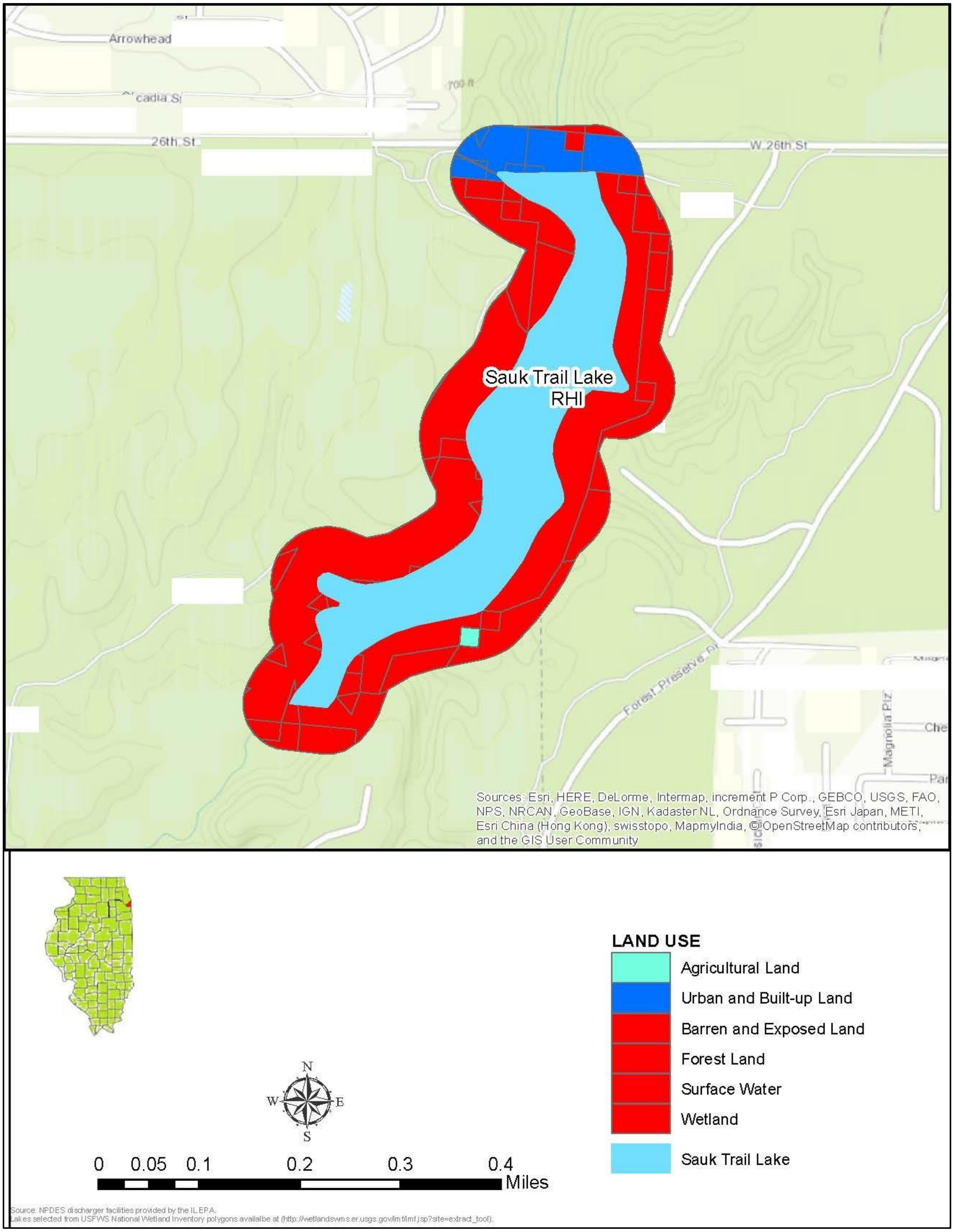


Figure 3-6: Sauk Trail Lake Segment RHI Buffer Land Uses Suitable for Conversion to Filter Strips

Wetlands could potentially be constructed at the lake where higher inflow rates are observed. The use of wetlands as structural controls was discussed in **Section 3.3**. For Sauk Trail Lake, hydric soils with potential for wetland construction are shown in **Figure 3-7**, along with existing wetlands, to indicate potential areas where wetlands may be installed for the lake's subbasin. Areas near the lake not currently classified as wetlands, but which have hydric soils present, are typically strong candidates for potential wetland construction. Existing wetland areas may also be candidates for reconstruction or enhancement to improve their nutrient uptake capacity. These data layers are developed on a large-scale and onsite soil investigation and wetland delineation is typically necessary for verification of the suitability of a given area for wetland construction.

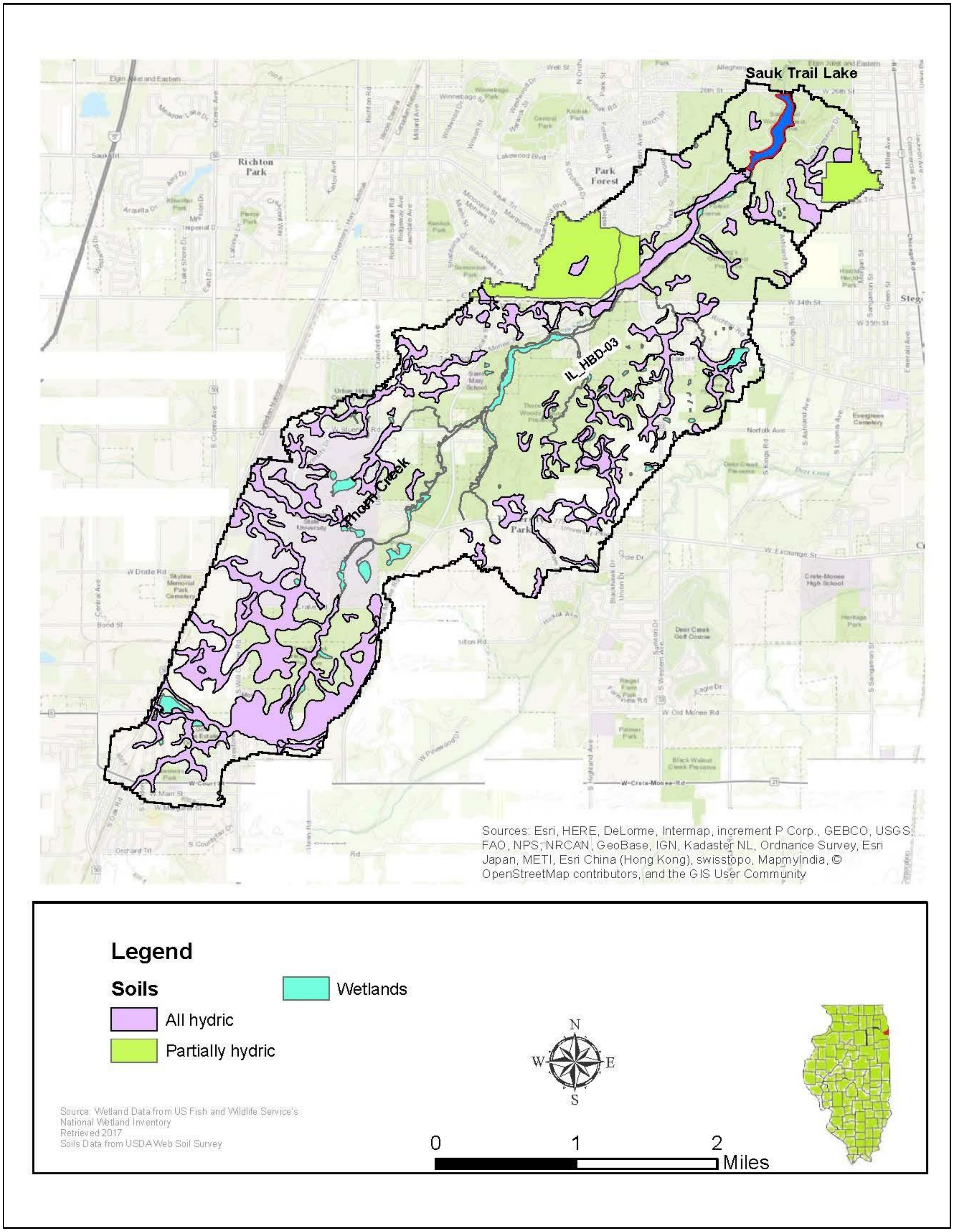


Figure 3-7: Sauk Trail Lake Segment RHI Hydric Soils and Wetlands

Shoreline stabilization/erosion control techniques could be used along the shoreline in select areas of the lake to deflect energy from water movement and minimize erosion. Techniques include engineered structures such as buried revetments and rip rap zones. The selected structures should be placed where higher inflow rates are observed and/or where erosion caused by wave action and other factors is observed.

- Buried revetments: These are passive, sloped, engineering structures designed to deflect energy associated with water movement and reduce erosion. The revetments are populated with native vegetation which can also reduce the transport of sediment associated pollutants via the control of shoreline soil erosion resulting from stormwater runoff.

The extent of bank erosion surrounding the Sauk Trail Lake is unknown. Further investigation is recommended to determine the extent that erosion control measures could help manage TSS loads in the lake.

3.5 BMP Recommendations for Reducing Total Phosphorus and Increasing DO in Sauk Trail Lake

As discussed in Section 3.4, Sauk Trail Lake is scheduled to be removed in 2021-2022. Sauk Trail Lake (RHI) has reported exceedances of the 0.05 mg/L water quality standard for total phosphorus in lakes and is therefore listed for impairment by total phosphorus. Phosphorus is a nutrient critical to healthy ecosystems at low concentrations; however, over enrichment of phosphorus can result in aquatic ecosystem degradation when nitrogen is also available in sufficient quantities. Nutrient enrichment can result in rapid algal growth as available nutrients and carbon dioxide are consumed. This response can alter pH, decrease DO (which is critical to other aquatic biota), alter the diurnal DO pattern, and even create anoxic conditions. In addition, nutrient enrichment can reduce water clarity and light penetration and is aesthetically displeasing. Oxygen levels must be considered when evaluating BMPs for phosphorus because phosphorus is released from sediment at higher rates under anoxic conditions; increased water temperature and photosynthesis decrease DO levels and create anoxic conditions.

Inputs of phosphorus originate from both point and nonpoint sources. Most of the phosphorus discharged by point sources is soluble. Phosphorus from point sources also typically has a continuous impact and is human in origin; for example, effluents from municipal sewage treatment plants and permitted industrial discharges. Phosphorus from nonpoint sources is generally insoluble or particulate. Most of this phosphorus is bound tightly to soil particles and enters streams from erosion. The impact from phosphorus discharged by nonpoint sources is typically intermittent and is most often associated with stormwater runoff. Sedimentation can impact the physical attributes of the stream and act as a transport mechanism for phosphorus.

Internal cycling of phosphorus from lake sediments is also a significant contributor to impairments in Sauk Trail Lake. Low DO near the lake bottom during periods of thermal stratification, if present, is generally addressed by focusing on organic loads that consume oxygen through decomposition as well as nutrient loads that can cause algal growth, which can also deplete DO. Sufficient reductions in nutrient loads are expected to alleviate DO issues.

Phosphorus loads in Sauk Trail Lake originate from internal and external sources. Possible external sources of total phosphorus include municipal point sources, lawn and garden activity, agriculture, runoff, and littoral/shore area modifications. To achieve a reduction of total phosphorus for the lake, managerial and institutional BMPs must address internal loading and loading associated with urban and rural runoff.

3.5.1 Point Sources of Phosphorus

While point source loads of phosphorus can be a significant issue in some watersheds, no point source discharges currently exist within the Sauk Trail Lake watershed. MS4 permitted areas do exist in the lake's subbasin; however, these are discussed along with non-MS4 stormwater and urban runoff in the following section.

3.5.2 Nonpoint Sources of Phosphorus

In addition to MS4 and non-MS4 urban stormwater, runoff from undeveloped and park lands are potential nonpoint sources of phosphorus pollution to the impacted lakes in the watershed. Due to the adsorbing nature of phosphorus, in which phosphorus adheres to sediment before being flushed into waterways, BMPs that could be used for treatment of these sources are similar to those discussed in **Section 3.3**, with the addition of in-lake management measures and phosphorus-based lawn fertilizer restrictions. BMPs evaluated that could be utilized to reduce phosphorus sources, in both urban and agricultural settings, include:

Urban BMPs:

- Grass Filter strips
- Urban Reforestation/Forested Riparian Buffer Restoration
- Wetlands
- Stormwater Retention Basins (dry and wet ponds)
- Vegetated Swales
- Permeable Pavement
- Sand Filters
- Compost Blankets, Filter Berms, and Filter Socks
- Stormwater Reduction Techniques
- Bio-Retention Cells
- Streambank Stabilization and Erosion Control
- Street Sweeping
- Phosphorus-based lawn fertilizer restrictions

Most of these BMPs are described in previous sections; however, additional details more specific to lakes are provided below.

A wetland, **stormwater retention basin**, **sand filtration basin**, and/or **bio-retention cell** could be constructed at the upstream end of Sauk Trail Lake. The use of these structural controls was generally discussed in **Section 3.3** and lake specific areas in **Section 3.4**. **Filter strips**; **riparian buffers**; **vegetated swales**; and **stormwater reduction techniques** may also be employed in select areas to help control overland flow and the associated transport of sediment and pollutants. Potential **filter strip** and **riparian buffer** areas for phosphorus control are the same as those for sediment/TSS control as discussed in **Section 3.4**.

In-Lake Phosphorus Loading: Modeling described in **Section 2** determined that internal loading of phosphorus is likely a significant contributor to overall watershed loads. A reduction of phosphorus from in-lake cycling through in-lake management strategies is necessary for attainment of the TMDL load allocations. Internal phosphorus loading can occur when the water above the sediments become anoxic, causing the release of phosphorus from the sediment in a form which is available for plant uptake. The addition of bioavailable phosphorus in the water column stimulates more plant growth and die-off, which may perpetuate or create anoxic conditions and enhance the subsequent release of phosphorus into the water. Internal phosphorus loading can also occur in shallow lakes through release from sediments by the physical mixing and reintroduction of sediments into the water column as a result of wave action, winds, boating activity, and other means.

For lakes experiencing high rates of phosphorus input from bottom sediments, several management measures are available to control internal loading. Three BMP options for the control of internal loading include the installation of an aerator, the addition of aluminum, and dredging.

- **Hypolimnetic (bottom water) aeration** involves an aerator air-release that can be positioned at a selected depth or at multiple depths to increase oxygen transfer efficiencies in the water column and reduce internal loading by establishing aerobic conditions at the sediment-water interface. Installation of an aeration device will also directly contribute to the alleviation of potential DO issues in lakes (Clean-Flo 2016).

- **Phosphorus inactivation by aluminum addition** (specifically aluminum sulfate or alum) to lakes is the most widely-used technique to control internal phosphorus loading. Alum forms a polymer that binds phosphorus and organic matter. The aluminum hydroxide-phosphate complex (commonly called alum floc) is insoluble and settles to the bottom, carrying suspended and colloidal particles with it. Once on the sediment surface, alum floc inhibits phosphate diffusion from the sediment to the water (Cooke et al. 1993).

- Phosphorus release from the sediment is greatest from recently deposited layers. **Dredging** approximately one meter of recently deposited phosphorus–rich sediment can remove approximately 80 to 90 percent of the internally loaded phosphorus without the addition of potentially toxic compounds to the reservoir. Dredging may also contribute to reductions in internal phosphorus loading by increasing the depth of large portions of the waterbody, reducing the degree of reintroduction of sediments into the water column through physical mixing. However, dredging is more costly than other management options (NRCS 2005).

Phosphorus-Based Lawn Fertilizer Restrictions: Runoff from urban areas may include phosphorus-based fertilizers applied to residential lawns, golf courses, and other surfaces. If used too close to a receiving waterbody, phosphorus present in stormwater runoff will enter the waterbody. Illinois has a statute in place which governs the use of phosphorus-based fertilizers in urban areas: Lawn Care Products Application and Notice Act (415 ILCS 65), and local enforcement of this ordinance by municipalities can make a significant reduction in phosphorus loading. This act includes the following prohibitions for phosphorus-based fertilizers (see act for limited exceptions):

- They shall not be applied to lawns unless it can be demonstrated by soil test that the lawn is lacking in phosphorus when compared against the standard established by the University of Illinois; see the act for exceptions
- They shall not be applied to impervious surfaces
- They shall not be applied within 3 feet of any waterbody if a spray, drop, or rotary spreader is used. If other equipment is used, the fertilizer may not be applied within 15 feet of a waterbody.
- They shall not be applied when the ground is frozen or saturated
- Appropriate lawn markers for the application event and notifications to potentially affected adjacent properties are required

In addition to enforcement of the above rules, BMPs should include education about the statute, and public outreach to increase awareness and compliance.

3.6 BMP Recommendations for Reducing Total Phosphorus and Increasing DO in Streams

Within the Thorn Creek watershed, Thorn Creek stream segments HBD-02, HBD-04, HBD-05, HBD-06, and Deer Creek segments HBDC and HBDC-02 were listed for impairment caused by total phosphorus. The total phosphorus reductions needed for each segment to meet the watershed-specific LRS target value were discussed in **Section 2.4.1**. To achieve the targeted reductions of total phosphorus for each segment, management measures should address loading through point source discharge and, in particular, nonpoint source sediment and surface runoff controls. Because the LRS process is intended to provide guidance (with no regulatory requirements) for voluntary nonpoint source reduction efforts by implementing stormwater BMPs

Thorn Creek segments HBD-02, HBD-03, HBD-04, and HBD-06; North Creek segment HBDA-01; and Deer Creek segment HBDC-02 are also listed for impairment by low DO. DO impairments are generally addressed by focusing on organic loads that consume oxygen through decomposition and nutrient loads that can cause algal growth, which can also deplete DO. Implementation actions initiated in Thorn Creek watershed for total phosphorus load reduction are directly applicable to DO issues as well. Sufficient reductions in nutrient loads to these stream segments are therefore expected to have positive impacts on instream DO levels. In addition, analyses discussed in **Section 2** established a relationship between low flows, SOD, nutrients, oxygen-demanding materials (BOD, ammonia-nitrogen, and organic nitrogen), and DO concentrations in the impaired segments; therefore, management measures for these segments will focus on decreasing loads of oxygen-demanding materials to increase DO concentrations.

DO impairments in the Thorn Creek watershed are mostly attributed to low flow or stagnant conditions. Runoff from nonpoint sources likely contributes loading of oxygen-demanding materials in each segment.

Figure 2-4 in the AECOM Stage 1 report for the Thorn Creek watershed (AECOM 2011) shows the land around the HBD-02, HBD-04, HBD-05, and HBD-06 segments to be primarily urban and forested. The figure also shows the lands around the HBDA-01, HBDC, and HBDC-02 segments to consist of urban, forested, and agricultural areas, with some of the agricultural lands immediately adjacent to portions of the impaired stream segments. Therefore, urban and agricultural BMPs are appropriate for different areas of the impaired stream sub-watersheds.

3.6.1 Point Sources of Phosphorus and Oxygen-Demanding Materials

Point sources discharging to impaired streams within the Thorn Creek watershed include municipal sewage treatment facilities and industrial dischargers. **Table 1-6** contains permit information on the treatment facilities, as well as model input parameters used in the QUAL2K modeling discussed in **Section 2** of this report. As discussed in **Section 1.5.2.6**, two large municipal treatment facilities discharge to, or upstream of, segments HBD-02, HBD-04, HBD-06, HBCD, and/or HBDC-02. Only one facility is currently subject to effluent limits for total phosphorus, and the other is only required to monitor for this parameter. The two existing POTW facilities also discharge oxygen-demanding materials, as measured by BOD. There are also numerous smaller dischargers that discharge phosphorus to the streams in the watershed. The facilities discharge to tributaries of the impaired segments, or in some cases, directly to the impaired stream segments. Percent reduction needs for total phosphorus and ammonia are discussed in **Section 2.3.5** and shown in **Tables 2-34** through **2-39**. While none of the stream segments are impaired specifically for ammonia, it can act as an oxygen-demanding material and reductions in this nutrient are therefore applicable.

Illinois EPA will evaluate the need for point source controls through the NPDES permitting program as each facility's permit is due for renewal. The NPDES permitted facilities' DMRs should continue to be monitored and any violations of the effluent limits at the permitted facilities may prompt further regulatory action.

MS4 permitted areas do exist in each stream's subbasin, however, these are discussed along with non-MS4 stormwater and urban runoff in the following section.

3.6.2 Stormwater Sources (both point and nonpoint) of Phosphorus and Oxygen-Demanding Materials

Potential stormwater-related inputs of nutrients to the impacted streams in the watershed include MS4 and non-MS4 urban runoff, and runoff from agricultural, undeveloped, and park lands. In addition, inputs are often caused by nutrient applications in urban settings, such as fertilizer inputs on lawns, golf courses, and other intensively used and maintained landscapes. Nutrients adsorb to soils and enters waterways with runoff and erosion, resulting in excessive growth of algae and other aquatic plants, which impairs aesthetics, water quality, and recreational potential.

BMPs that could be used for treatment of these nonpoint sources are similar to those discussed in **Section 3.3**, with the addition of phosphorus-based lawn fertilizer restrictions, as discussed in **Section 3.5.2**. BMPs evaluated that could be utilized to treat nonpoint phosphorus sources therefore include:

- Grass Filter strips
- Urban Reforestation/Forested Riparian Buffer Restoration
- Wetlands
- Stormwater Retention Basins (dry and wet ponds)
- Vegetated Swales
- Permeable Pavement
- Sand Filters
- Compost Blankets, Filter Berms, and Filter Socks
- Stormwater Reduction Techniques
- Bio-Retention Cells
- Streambank Stabilization and Erosion Control
- Street Sweeping
- Phosphorus-based lawn fertilizer restrictions
- Nutrient management (for agricultural areas)

Most of these BMPs are described in previous sections; however, additional details more specific to streams are provided below.

Filter Strips: As discussed in **Section 3.3**, filter strips can be used as a control to reduce a variety of pollutant loads from runoff, including phosphorus and oxygen-demanding materials. The calculations associated with development of filter strip areas for TSS and sediment control described in **Section 3.3** are directly applicable to total phosphorus loads as well. In addition, the Illinois Urban Manual describes long term phosphorus removal efficiencies, or treatment factors, of filter strips of various slopes in urban environments and for different soil types. **Table 3-6** provides a summary of the treatment factors for wooded and non-wooded filter strips in urban areas (AISWCD 2013a). See **Table 3-2** and **Figures 3-1** through **3-3** for areas which can potentially be converted to filter strips.

Table 3-6: Filter Strip Treatment Factors based on Land Slope – Wooded (Non-Wooded)

Hydrologic Soil Group	Slope	25 ft	50 ft	100 ft	150 ft	200 ft
A	0-10%	.75 (.95)	.4 (.6)	.2 (.4)	.1 (.3)	0 (.2)
	11-15%	.8 (1.0)	.5 (.7)	.25 (.45)	.1 (.3)	0 (.2)
	16-20%	.8 (1.0)	.7 (.9)	.5 (.7)	.25 (.45)	.1 (.3)
	21-30%	.8 (1.0)	.75 (.95)	.7 (.9)	.6 (.8)	.3 (.6)
B	0-10%	.75 (.95)	.6 (.8)	.4 (.6)	.2 (.4)	.1 (.2)
	11-15%	.8 (1.0)	.75 (.95)	.5 (.7)	.2 (.4)	.1 (.2)
	16-20%	.8 (1.0)	.8 (1.0)	.65 (.85)	.4 (.6)	.2 (.4)
	21-30%	.8 (1.0)	.8 (1.0)	.7 (.9)	.5 (.7)	.3 (.6)
C	0-10%	.8 (1.0)	.7 (.9)	.55 (.75)	.45 (.65)	.35 (.55)
	11-15%	.8 (1.0)	.75 (.95)	.6 (.8)	.5 (.7)	.4 (.65)
	16-20%	.8 (1.0)	.8 (1.0)	.7 (.9)	.6 (.8)	.5 (.65)
	21-30%	.8 (1.0)	.8 (1.0)	.75 (.95)	.65 (.85)	.5 (.75)
D	0-10%	.9 (1.0)	.8 (.65)	.75 (.8)	.7 (.8)	.6 (.75)
	11-15%	.9 (1.0)	.85 (1.0)	.8 (.9)	.75 (.9)	.65 (.8)
	16-20%	.9 (1.0)	.9 (1.0)	.85 (1.0)	.8 (1.0)	.7 (.85)
	21-30%	.9 (1.0)	.9 (1.0)	.9 (1.0)	.8 (1.0)	.75 (.9)

Forested Riparian Buffers: As discussed in **Section 3.3**, riparian buffers can be used as a control to reduce a variety of pollutant loads from runoff, including phosphorus and oxygen-demanding materials. The vegetation also serves to reinforce streambank soils, which helps minimize erosion, and the shade provided will reduce solar radiation loading to the stream and will reduce peak temperatures seasonally, as well as limit algal growth, thereby mitigating low DO levels. The calculations associated with development of riparian buffer areas for TSS and sediment control described in **Section 3.3** are directly applicable to total phosphorus loads as well. See **Table 3-3** for areas which can potentially be converted to riparian buffers.

The Thorn Creek Headwaters Preserve is one BMP that will create stream improvements for segment HBD-03 and segments downstream. This is a 426-acre property acquired by the Forest Preserve District of Will County in 2007-2008. It is currently mostly farmland, but according to the Forest Preserve District's 2014 Thorn Creek Greenway Preserve Improvement and Management Plan, the future goal for this area is to restore it to native prairie and wetland communities. Two projects have already restored a portion of the preserve, as described below under "Wetlands".

Wetlands: The use of wetlands as a structural control was discussed for TSS and sedimentation/siltation for both streams and lakes. Wetlands are also applicable to nutrient reduction from urban lands because they facilitate plant nutrient uptake, thereby filtering water of pollutants (NRCS 2014). A wetland could be constructed anywhere space allows. Existing wetlands may need to be rehabilitated.

Two recent BMP projects occurred in the watershed of Thorn Creek segment HBD-03, both within the Thorn Creek Headwaters Preserve. First, a wetland mitigation project was implemented in 2014. Ninety-three acres were restored to wetland and prairie to compensate for impacts of the IDOT Stuenkel Road/I-57 Interchange project. The second project was the addition of infiltration and a constructed wetland at Will-Center Road, a cooperative project between the Forest Preserve District of Will County and the Village of University Park.

Stormwater Retention Basins: As discussed in **Section 3.3**, these control basins and ponds ("dry" or "wet") may be used for flood control and treatment of stormwater. Both systems function to settle suspended sediments and other solids typically present in stormwater runoff. In retaining sediment within the basin, nutrients and trace metals can be removed from overland flow/stormwater runoff before it enters the streams.

Vegetated swales, **permeable pavement**, **sand filters**, **stormwater reduction techniques**, **bio-retention cells**, **streambank stabilization** measures, and **street sweeping** will reduce the amount of phosphorus impacted soils and oxygen-demanding materials entering the streams. A reduction in nutrient loads will decrease the biological productivity and, along with the decreased inputs of oxygen-demanding materials, will lead to a reduction in the levels of SOD present in the stream. Instream management measures for DO focus on reaeration techniques such as rock riffles. **Phosphorus-based lawn fertilizer restrictions** are the same as described in **Section 3.5.2**.

Nutrient Management: As noted above, several areas of agricultural land are present in the watershed, including along the impaired Deer Creek segments. Nutrient management programs for these areas could result in reduced nutrient loads to the phosphorus-impaired stream segments in the watershed. Crop management of nitrogen and phosphorus originating in the agricultural portions of the watershed can be accomplished through Nutrient Management Plans (NMPs) that focus on increasing the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface water and groundwater.

The overall goal of nutrient reduction from agriculture should be to increase the efficiency of nutrient use by balancing nutrient inputs in feed and fertilizer with outputs in crops and animal produce as well as to manage the concentration of nutrients in the soil. The four "Rs" of nutrient management are applying the right fertilizer source at the right rate at the right time and in the right place. It is not unusual for crops in fields or portions of fields to show nutrient deficiencies during periods of the growing season, even where an adequate NMP is followed. The fact that nutrients are applied does not necessarily mean they are available. Plants obtain most of their nutrients and water from the soil through their root system. Any factor that restricts root growth and activity has the potential to restrict nutrient availability and result in increased nutrient runoff.

Reducing nutrient loss in agricultural runoff may be brought about by source and transport control measures, such as filter strips or grassed waterways. The NMPs account for all inputs and outputs of nutrients to determine reductions. NMPs typically include the following measures:

- A review of aerial photography and soil maps
- Recommendation for regular soil testing – Traditionally, soil testing has been used to decide how much lime and fertilizer to apply to a field. With increased emphasis on precision agriculture, economics, and the environment, soil tests have become a logical tool to determine areas where adequate or excessive fertilization has taken place. Additionally,

they can be used to monitor nutrient buildup in soils due to past fertility practices and aid in determining maintenance fertilization requirements. Appropriate soil sampling and analysis techniques are described in the Illinois Agronomy Handbook (http://extension.cropsciences.illinois.edu/handbook/).

- A review of current and/or planned crop rotation practices
- Establishment of yield goals and associated nutrient application rates – Matching nutrient applications to crop needs will minimize the potential for excessive buildup of phosphorus soil tests and reallocate phosphorus sources to fields or areas where they can produce agronomic benefits.
- Development of nutrient budgets with planned application rates (which may be variable), application methods, and timing and form of nutrient application
- Identification of sensitive areas and restrictions on application when land is snow covered, frozen or saturated

Phosphorus is listed as a potential cause of impairment in many stream segments in the Thorn Creek watershed. Regional differences in phosphorus-supplying power are shown in Figure 8-4 of the Illinois Agronomy Handbook (http://extension.cropsciences.illinois.edu/handbook/). The differences were broadly defined primarily based on variability in parent material, degree of weathering, native vegetation, and natural drainages. For example, soils developed under forest cover appear to have more available subsoil phosphorus than those developed under grass. In the Thorn Creek watershed in northeastern Illinois, soils are generally considered to have low phosphorus-supplying power; therefore, buildup and maintenance of phosphorus levels are sometimes needed in this area. Application amounts should be determined by periodic soil testing; however, excessively high-phosphorus soil test levels should not be maintained.

While soil test procedures were designed to predict where phosphorus was needed, not to predict environmental problems, the likelihood of phosphorus loss increases with high-phosphorus test levels. Environmental decisions regarding phosphorus applications should include such factors as distance from a significant lake or stream, infiltration rate, slope, and residue cover. One possible problem with using soil test values to predict environmental problems is in sample depth. Normally samples are collected to a 7-inch depth for predicting nutritional needs. For environmental purposes, it would often be better to collect the samples from a 1- or 2-inch depth, which is the depth that will influence phosphorus runoff. Another potential problem is variability in soil test levels within fields in relation to the dominant runoff and sediment-producing zones. Several fertilizer placement recommendations are described in the Illinois Agronomy Handbook. However, given the propensity of phosphorus to bind tightly to soil particles and subsequently enter streams through erosion, the deep fertilizer placement technique may be most appropriate in phosphorus impaired areas such as the Thorn Creek watershed. Under the deep placement technique, the fertilizer is placed 4 to 8 inches deep into the soil rather than being spread near the surface.

3.7 BMP Recommendations for Reducing Fecal Coliform in Streams

The TMDL analyses performed for fecal coliform bacteria in Thorn Creek segments HBD-02, HBD-03, HBD-04, HBD-05, and HBD-06; Butterfield Creek segment HBDB-03; and Deer Creek segments HBDC and HBDC-02 show that exceedances have been reported over the full range of flow conditions. Elevated fecal coliform concentrations reported during higher flow conditions are likely a result of stormwater runoff and re-suspension of instream fecal material. Elevated fecal coliform concentrations occurring under low flow conditions are likely a result of point source contributions, illicit sewer connections, and/or groundwater inputs.

3.7.1 NPDES Permitted Point Sources of Fecal Coliform

Section 2.3.1.4 discusses NPDES permitted sources for fecal coliform. These sources consist of two large POTWs (Thorn Creek Sanitary District STP and Aqua Illinois – University Park WWTF), two excess-flow POTWs (Homewood Excess Flow Treatment Plant and Park Forest Excess Flow Facility) and two small mobile home park treatment plants (Ely's Mobile Home Park STP and Paradise Park MHP STP). The facilities are located both on tributaries of the impaired segments and, in some cases, directly discharge effluent to the impaired stream segments. WLAs for fecal coliform were calculated for each facility as described in **Section 2.3.1.4** and are shown in **Table 2-4.**

A number of municipalities and townships within the Thorn Creek watershed have MS4s. WLAs for the MS4 dischargers were calculated based on municipality boundaries, available information obtained from the MWRD, and the proportion of total MS4 area to total watershed area as discussed in **Section 2.3.1.4**. The total MS4 load allocations for fecal coliform applied to the proportion of each municipality within each impaired reach's subbasin are shown for each applicable flow category in **Tables 2-5** through **2-12.**

Municipalities covered by MS4s are encouraged to review their stormwater plans to ensure that effective BMPs are being used within their systems. Additionally, municipalities should perform assessment and monitoring to find, fix, and prevent illicit discharges. Illicit discharges may be defined as a storm drain that has measurable flow during dry weather containing pollutants and/or pathogens. A storm drain with measurable flow but containing no pollutants is simply considered a discharge. Illicit discharges are frequently caused when the sewage disposal system interacts with the storm drain system. Each illicit discharge has a unique frequency, composition, and mode of entry in the storm drain system. Illicit discharges of other pollutants are produced from specific source areas and operations known as "generating sites." Knowledge about these generating sites can be helpful to locate and prevent non-sewage illicit discharges. Depending on the regulatory status of specific "generating sites," education, enforcement and other pollution prevention techniques can be used to manage this class of illicit discharges.

The highest priority in most illicit discharge monitoring programs is to find any continuous and intermittent sewage discharges to the storm drain system. A variety of monitoring techniques can be used to find the problem areas and then trace the problems back up the stream or pipe to identify the ultimate generating site or connection. Monitoring can sometimes pick up other types of illicit discharge that occur on a continuous or intermittent basis (e.g., wash water and liquid wastes). Monitoring techniques which can be used to find, fix, and prevent illicit discharges include:

- Outfall reconnaissance inventory, including documenting outfall locations and global positioning system coordinates, as well as investigating them for dry weather flow.
- Indicator monitoring at stormwater outfalls and in-stream. This would include collecting samples for fecal coliform analysis.
- Tracking discharges to their source. If detected, the fecal samples can be sourced to find out if it's animal or human. If it's human the pipes/conveyances can be tracked back to find a cross-connection and eliminate it.

Once sewage discharges or other connections are discovered, they can be fixed, repaired or eliminated through several different mechanisms. Communities should establish targeted education programs along with legal authority to promote timely corrections. A combination of rewards and penalties should be available to deal with the diversity of potential dischargers.

Transitory discharges from generating sites can be minimized through pollution prevention practices and well-executed spill management and response plans. These plans should be frequently practiced by local emergency response agencies and/or trained workers at generating sites.

3.7.2 Nonpoint Sources of Fecal Coliform

Several management options have been identified to help reduce fecal coliform counts in the Thorn Creek watershed. These management options focus on the most likely sources of fecal coliform within the basin, such as wildlife, domestic pets, and overland stormwater runoff. Other nonpoint sources for fecal coliform can include septic systems. While the entirety of the watershed is currently within the service area of a municipal sewer system, functional or abandoned septic systems potentially still exist within the watershed, the existence and prevalence of which is not known. BMPs for fecal coliform were originally discussed in **Section 3.3**.

Sand filtration basins, **stormwater retention ponds**, and **bio-retention cells** could be constructed near discharge areas to streams. **Filter strips** and **riparian buffers** may also be employed in select areas to help control overland flow and the associated transport of sediment and pollutants. Potential **filter strip** areas for fecal coliform control are the same as those for sediment/TSS control as discussed in **Section 3.3** (**Table 3-2** and **Figures 3-1** through **3-3**). Similarly, potential **riparian buffer** areas for fecal coliform control are the same as those for sediment/TSS control as discussed in **Section 3.3** (**Table 3-3**).

Domestic pet waste: According to the Stage 1 TMDL report (AECOM 2011) approximately 200,000 people resided in the Thorn Creek watershed in 2000. Information on the number of people with pets is not available; however, there are still likely several thousand domestic pets within the watershed. Education of pet owners on the potential impacts of pet waste to streams and lakes should occur periodically. Public meetings; mass mailings; and radio, newspaper, and

TV announcements can all be used to remind and inform owners of their responsibility to pick up after their pets.

Septic System Maintenance: Failing or leaking septic systems can be a significant source of fecal coliform pollution. A program that actively manages functioning systems and addresses non-functioning systems could be implemented to reduce the potential bacteria loads from septic systems in the watershed. The USEPA has developed guidance for managing septic systems, which includes assessing the functionality of systems, public health, and environmental risks (USEPA 2005). It also introduces procedures for selecting and implementing a management plan.

It is unclear to what extent businesses, residences, and other structures in the various townships are served by septic vs. municipal sewer systems; however, as noted above, the entirety of the watershed is currently within the service area of a municipal sewer system. If functional or abandoned septic systems still exist within the watershed, these are expected to be limited in number.

The degree of nutrient removal in any existing systems is limited by soils and system upkeep and maintenance. To reduce the discharge of excessive amounts of contaminants from a faulty septic system, a scheduled maintenance plan that includes regular pumping and maintenance of the septic system should be followed. The majority of failures originate from excessive suspended solids, nutrients, and BOD loading to the septic system. Reduction of solids entering the tank can be achieved by limiting the use of garbage disposals.

Septic system management practices can extend the life, and maintain the efficiency, of a septic system. Water conservation practices, such as limiting daily water use or using low flow toilets and faucets, are the most effective methods to maintain a properly functioning septic system. Additionally, septic systems should not be used for the disposal of solids, such as cigarette butts, cat litter, cotton swabs, coffee grounds, disposable diapers, etc. Physical damage to the drain field can be prevented by:

- Maintaining a vegetative cover over the drain field to prevent erosion
- Avoiding construction over the system
- Protecting the area down slope of the system from excavation
- Landscape the area to divert surface flow away from the drain field (Johnson 1998)

The cost of each management measure is highly variable and site-specific data on septic systems and management practices do not exist for the watershed; therefore, homeowners with septic systems should contact their county health department for septic system management costs.

Current protocols for addressing failing septic systems should adhere to the Illinois Private Sewage Disposal Licensing Act and Code "to prevent the transmission of disease organisms, environmental contamination and nuisances resulting from improper handling, storage, transportation and disposal from private sewage disposal systems". Any new, replaced, or renovated system must be installed by a licensed contractor or the homeowner and permitted through the county health department. The department must receive both an application for permit and the appropriate fee from the contractor/homeowner. Once reviewed and approved, a permit is issued and an inspection of the system is conducted during and after construction. The county health department also investigates private sewage disposal system complaints.

A long-range solution to failing septic systems is connection to a municipal sanitary sewer system. Connection to a sanitary sewer line would reduce existing phosphorus sources by replacing failing septic systems with municipal treatment and will allow communities to develop without further contribution of pollutants to impaired waterbodies. Costs for the installation are generally paid over a period of several years (average of 20 years) and help to avoid forcing homeowners to shoulder the entire initial cost of installing a new septic system. In addition, costs are sometimes shared between the community and the utility responsible for treating the wastewater generated from replacing the septic tanks. The planning process is involved and requires participation from townships, cities, counties, businesses, and citizens.

3.8 BMP Recommendations for Reducing Chloride in Streams

Chloride is a conservative ion, does not degrade, and has the potential to accumulate within waterbodies over time. Chloride is toxic to aquatic organisms at high concentrations and, even at lower concentrations, chloride may impact biological community structure, diversity, and productivity. Chloride salts can also affect soil stability and permeability and increase the potential for erosion. Within the Thorn Creek watershed two segments of Thorn Creek (HBD-04 and HBD-06) were listed for impairment of the aquatic life use due to water quality standard exceedances. Reductions of chloride loads needed to meet the TMDL for the impaired segments are discussed in **Section 2.3.2**.

3.8.1 Point Sources of Chloride

There are twelve NPDES permitted point sources present within the Thorn Creek watershed, and these facilities are located both on tributaries of the impaired segments and, in some cases, they directly discharge effluent to the impaired stream segments. Only two of the listed facilities, Aqua Illinois – University Park WWTF and Park Forest WTP have discharge monitoring requirements for chloride. WLAs were calculated for these facilities based on their permitted effluent limits of 500 mg/L. This effluent limit is the same as the most conservative water quality standard and TMDL endpoint of 500 mg/L.

Chloride WLAs for MS4 discharges were calculated as discussed in **Section 2.3.2.4**. Total MS4 load allocations for chloride for municipalities within each impaired reach's subbasin are shown in **Tables 2-23** and **2-24.**

Continued and/or future monitoring of chloride concentrations in effluent from each of the facilities within the watershed will help provide greater certainty on the relative impact of dischargers to the chloride concentrations in the impaired segments.

3.8.2 Nonpoint Sources of Chloride

Land use around the Thorn Creek watershed is approximately 58% urban overall, with denser urban areas towards the downstream end of the watershed. Nonpoint chloride sources may therefore originate from road de-icing activities using chloride salts. While all of the BMPs listed for TSS and fecal coliform will also benefit the chloride impairment, particularly vegetated swales since they generally line roadways, the following BMPs are specific to chloride and will provide a basis for management of chloride salt application to roadways:

Public Education and Staff Training: Educating the public is generally the first step in any water quality improvement campaign. Increased awareness about the application of road salt and the effects of excessive loading to waterbodies can increase community support for chloride use reduction. Information about what homeowners and businesses can do to limit chloride salt application in addition to municipal leadership should be included. The following elements could be included in the public education program:

- Informative fact sheets for public distribution. Environmental group outreach lists can be useful and the information could be in a general, adaptive form.
- Presentation or fact sheets targeted to municipal government officials.
- Public access television.
- Newspaper articles or advertisements.
- Declaration of "Limited Salt Use Areas" to highlight water quality protection and increase awareness.

Staff training is critical to reduce the quantity of road salt used as operators responsible for salt handling and application can have the largest impact on overuse and product loss. Elements of a staff training program could include:

- Initial training for new employees, including on-the-job training from experienced personnel. Alternatively, programs are offered by the American Public Works Association and Northeastern Illinois Public Safety Training Academy.
- Routine annual refresher training for salt handling and application with operators highlighting the impacts of road salt on water quality, infrastructure, and associated costs to the public. Proper storage and handling and application equipment and techniques should be covered as well, including record keeping and a review of the salt quantities required for each situation.
- Required training for private snow removal contractors generally involved in parking lot and private road snow removal. This could be done through a licensing or permitting process.

Storage and Handling: Proper storage and handling of road salt limits loss of salt to the environment and provides cost savings. The Salt Institute has published a Salt Storage Handbook (Salt Institute 2015) with recommended practices and design criteria for storage facilities. Additionally, the Transportation Association of Canada has published detailed BMPs for salt storage (TAC 2013). The Illinois Department of Transportation already has standard designs which can be adopted by municipalities. Existing facilities should be evaluated for improvement and bulk handling practices reviewed. Areas on which to focus evaluation should include protection from environmental conditions like wind and rain, storage on an impervious pad, and controlled offsite drainage. Training on proper handling and equipment inspection practices should include:

- Salt should be handled as little as possible to avoid particle breakdown and loss of material.
- Spillage should be minimized and cleaned up as soon as practicable.

Application: Proper application of salt for snow and ice control is fundamental to obtaining the desired effect of public road safety while minimizing product loss to the environment. Several guidelines and recommendations have been published including the salt Spreading, Maintenance, Application Rates & Timing (SMART) Learning Guide BMPs by the Transportation Association of Canada (TAC 2005) and the Minnesota Local Road Research Board handbook for snowplow operators (LRRB 2012), which was written in conjunction with the Minnesota Department of Transportation.

Records should be kept of salt use for each route, during each storm, by each vehicle, and by each operator. The records should be examined regularly to confirm that the target salt application rates are being met. Plowing snow just prior to salt application is good practice and if side-cast snow accumulation interferes with continued plowing, it should be removed to an offsite disposal facility. There are two alternative application methods which could increase the effectiveness of traditional rock salt application during and after snow events described below.

- Use of a pre-wetting agent has been shown to reduce wasted salt during application, thereby requiring less material and chemicals (Fay et al. 2013). Pre-wetted salt is also more effective than dry salt, in a wider range of temperatures, in terms of de-icing capabilities, as well as adherence to the road surface. Pre-wetting can be done onboard spreader trucks or by pre-treating salt stockpiles before loading trucks.
- Anti-icing programs should strongly be considered in conjunction with deicing programs. This involves the application of deicing agents on roads prior to ice or snow events. Correct timing for application involves use of accurate weather forecasts or weather information systems. These systems may require purchase or equipment modification and employee training.

Alternative Products: Non-chloride deicing products are available for purchase and agencies have well documented their use. It is recommended that a long-term pilot study be done within the watershed to determine effectiveness for this application. Acetate deicers do not contain chloride, but can be relatively expensive. Organic deicers are also relatively expensive, but can be used in select areas, or in combination with other deicing liquids. More detailed information can be found in the Chloride Usage Education and Reduction Program Study (DRSCW 2007) by the DuPage River Salt Creek Workgroup.

3.9 BMP Recommendations for Reducing Silver and Zinc in Streams

Thorn Creek segment HBD-02 is listed for both zinc and silver impairments. Segment HBD-02 requires a 2.6% reduction in silver inputs at mid-range flows and no reduction at higher or lower flows, indicating uncertainty as to whether point or nonpoint sources are responsible. The exceedances as discussed in **Section 1.5.2.5** potentially suggest that the primary source of silver loads into the impaired segment are likely in response to overland runoff and urban stormwater resulting from precipitation events. Segment HBD-02 requires a 30-34% reduction in zinc inputs at high flows and higher moist flows, and a 6% to 16% reduction at lower moist to low flows. Zinc reduction needs indicate that both point and some nonpoint sources are responsible (**Section 1.5.2.4**).

Silver and zinc are common pollutants from industrial sources. Nonpoint sources of zinc include aging galvanized iron and steel, road salt, and tire wear (Schueler and Shepp 1993). Silver has a variety of uses such as photographic purposes, coins, electrical and electronic uses, solder, solar energy, jewelry, and sterling silver and silver electroplated objects.

Zinc can combine with other elements, such as chlorine, oxygen, and sulfur, to form zinc compounds. Most zinc ore found naturally in the environment is in the form of zinc sulfide. Zinc mobility and bioavailability is mainly governed by pH. As with many trace metals, zinc solubility is higher under more acidic conditions. Alkaline conditions favor adsorption of zinc to oxides and oxyhydroxides of iron, manganese, and aluminum; and to clay minerals and organic matter; and sorption and/or precipitation with carbonate minerals. Organic matter appears to play a more important role on zinc adsorption as compared to the hydroxides. Under low reduction-oxidation conditions, zinc may form insoluble sulfides. Naturally-occurring chelating agents, such as many organic acids, can increase the solubility and mobility of zinc.

Silver is found in both elemental form and in various ores such as argentite (silver sulfide) and horn silver (silver chloride). Commercially, the main sources of silver are copper, copper-nickel, gold, lead, and lead-zinc ores. Silver is also extracted from the anode waste sludges of electrolytic copper-refining. Silver is stable in oxygen and water, but tarnishes when exposed to sulfur compounds in air or water to form a black sulfide layer. Inorganic and organic components of water influence silver speciation in waste water effluent and may affect silver toxicity. Cationic and anionic constituents of aqueous systems control ionic strength which affect metal solubility. Organic materials such as humic and fulvic acids are capable of complexing silver and other metals in solution. It is also entirely possible that silver combines with ions and/or organic material to form suspended solids which are measured as aqueous silver. This suspended silver may be less available for bioaccumulation than soluble forms of silver. Lower bioavailability of silver reduces the toxicity observed for silver solutions.

3.9.1 Point Sources of Silver and Zinc

Dischargers within the Thorn Creek watershed tributary to segment HDB-02 are discussed in **Sections 2.3.3.4** and **2.3.4.4**. One permittee is required to monitor for both silver and zinc, one permittee is required to monitor for zinc, and one permittee is required to monitor for silver; however, none of these permittees have permit limits for these metals. None of the other permittees have permit limits or monitoring requirements for silver. One permittee, a POTW, has permit limits for zinc. No point sources have been identified in the watershed that discharge high concentrations of silver or zinc. Continued and/or future monitoring of zinc and silver concentrations in effluent from each permitted facility within the watershed will help provide greater certainty on the relative impact of dischargers to the zinc and silver concentrations in the impaired segment.

MS4 load allocations for zinc and silver for municipalities within the impaired reach's subbasin are also discussed in **Sections 2.3.3.4** and **2.3.4.4**. BMPs for the MS4s are discussed along with non-MS4 stormwater and urban runoff in the following section.

3.9.2 Nonpoint Sources of Silver and Zinc

In addition to MS4 and non-MS4 urban stormwater, runoff from undeveloped, park, and agricultural lands are potential nonpoint sources of zinc and silver pollution to the impacted stream segment. The following BMPs are recommended to reduce the loading of silver and zinc to Thorn Creek.

For naturally-occurring nonpoint sources, filter strips, stormwater retention basins, vegetated swales, and streambank stabilization/erosion control practices may provide the secondary benefit of reducing any contaminants that may be attached to the soil, primarily by limiting the amount of zinc- or silver-enriched sediment or water flowing into the stream segment. These control practices were described in **Section3.3**.

Additional BMPs for zinc and silver include chemical or passive treatment methods. Active chemical treatment typically involves the addition of other chemicals, such as calcium carbonate, sodium hydroxide, sodium bicarbonate, and anhydrous ammonia, to create a reaction, decrease the solubility of dissolved metals, and precipitate metal salts which then settle out of solution. Active chemical treatment is not likely to be a viable option for the HBD-02 stream segment because the chemicals are expensive and the treatment system requires additional costs associated with operation and maintenance, as well as the disposal of metal-laden sludge. Chemical addition and energy consuming treatment processes are virtually eliminated with passive treatment systems, and the operation and maintenance requirements of passive systems are considerably less than active treatment systems. Examples of passive treatment technologies include the following:

Aerobic Wetland: An aerobic wetland consists of a large surface area pond with horizontal surface flow. These wetlands can only effectively treat water that is net alkaline (pH greater than 7). In aerobic wetland systems, metals are precipitated through oxidation reactions to form oxides and hydroxides. A typical aerobic wetland will have a water depth of 6 to 18 inches and can be planted with cattails and other wetland species (Zipper et al. 2011).

Compost or Anaerobic Wetland: Compost, or anaerobic, wetlands, consist of a large pond with a lower layer of organic substrate. A typical compost wetland will have 12 to 24 inches of organic substrate and be planted with cattails or other emergent vegetation (Zipper et al. 2011). Typically, the compost layer consists of spent mushroom compost that contains about 10 percent calcium carbonate. Other compost materials include peat moss, wood chips, sawdust, or hay. The flow is horizontal within the substrate layer of the basin. Piling the compost a little higher than the free water surface can encourage the flow within the substrate.

Open Limestone Channels: Open limestone channels may be the simplest passive treatment method available. These channels are constructed in two ways. The first method collects contaminated drainage water within a drainage ditch constructed of limestone while the second method consists of placing limestone fragments directly in a contaminated stream. In either case, dissolution of the limestone adds alkalinity to the water and raises the pH causing precipitation of the metals. This treatment requires large quantities of limestone for long-term success (Zipper et al. 2011).

Diversion Wells: Diversion wells are another simple way to increase the alkalinity of contaminated waters. Acidic water is conveyed by a pipe to a downstream "well," which contains crushed limestone aggregate. The hydraulic force of the pipe flow causes the limestone to turbidly mix and abrade into fine particles preventing armoring (Zipper et al. 2011).

Anoxic Limestone Drains: An anoxic limestone drain is a buried bed of limestone constructed to intercept subsurface mine water flow and prevent contact with atmospheric oxygen. Keeping oxygen out of the water prevents oxidation of metals and armoring of the limestone. An anoxic limestone drain can be considered a pre-treatment step to increase alkalinity and raise pH before the water enters a constructed aerobic wetland (Zipper et al. 2011).

Vertical Flow Reactors: Vertical flow reactors were conceived as a way to overcome the alkalinity producing limitations of anoxic limestone drains and the large area requirements of compost wetlands. The vertical flow reactor consists of a treatment cell with an under-drained limestone base topped with a layer of organic substrate and standing water. The water flows vertically through the compost and limestone and is collected and discharged through a system of pipes. The vertical flow reactor increases alkalinity by limestone dissolution and bacterial sulfate reduction (Zipper et al. 2011).

3.10 Cost Estimates of BMPs

Cost estimates and payment rate estimates for a number of suggested BMPs are provided in the following sections. For some BMPs, “average” costs are not available due to design considerations such as size, construction materials, and site-specific conditions. Information for **Sections 3.10.1** through **3.10.3** was obtained from the Illinois EQIP List of Eligible Practices and Payment Schedule documents located at (https://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/#eqipbene).

3.10.1 Filter Strips and Riparian Buffers

Several types of filter strip practices are available, including areas for native herbaceous vegetation with or without fertility measures required and areas of introduced species, also with or without fertility measures required. Filter strip implementation that includes seedbed preparation and native seed application ranges from $520/acre to $639/acre depending on the type used.

Riparian buffers consisting of trees and shrubs can vary in costs depending on the type of material planted and the density of plantings required. Per unit costs and payments for bare-root trees and shrubs are estimated at $1.65 per tree and $1.10 per shrub. Direct seeding of trees and/or shrubs costs approximately $741/acre. The direct seeding scenario includes a planting rate of approximately 3,000 seeds per acre and both include the foregone income for the land taken out of crop production. Land preparation, including removing undesirable vegetation and improving site conditions, is estimated at $38-42/acre. For cases where an herbaceous cover is preferable, such as native grass or certain species of forbs and/or shrubs, costs/payments average $662/acre.

3.10.2 Nutrient Management Plan – NRCS

According to the Stage 1 report (AECOM 2011), only about 19% of the Thorn Creek watershed is comprised of agricultural land; however, areas where agricultural land does exist may benefit from NMPs. Estimated costs and EQIP payments for nutrient management range from $13/acre (basic) to $45/acre (enhanced nutrient management with deep placement [at least 4 inches below surface] of manure and/or phosphorus fertilizer). The cost for developing a NMP ranges from $1,740 to $2,901/plan depending on the acreage to be managed under the plan and assuming that a comprehensive NMP is not required. NMP preparation includes soil testing, manure analysis, scaled maps, and site-specific recommendations for fertilizer management.

3.10.3 Nutrient Management Plan – IDA and Illinois EPA

The costs associated with development of a NMP co-sponsored by the Illinois Department of Agriculture (IDA) and the Illinois EPA is estimated at $10/acre paid to the producer and $3/acre for the third party vendor who develops the plan. There is a 200 acre cap per producer. The total plan development cost is estimated at $13/acre.

3.10.4 Wetlands

The price to establish a wetland is very site specific and depends on factors such as size and type of vegetation used. Examples of costs associated with constructed wetlands include excavation costs, vegetation removal, and revegetation costs. Costs for wetlands created on a flat mineral uplands where surface runoff may be intercepted and ponded by excavation range from $3,186 (no embankment) to $3,679 (with embankment). Some areas may favor a wetlands setting requiring only to be enhanced or restored. In an area of natural depression fed by surface runoff, enhancement/restoration is approximately $2,557/acre. Enhancing or restoring a wetland on a floodplain site that has existing levees and/or ditches may consist of regrading or shaping the land, potentially including levee removal, for $1,167/acre. Constructed wetlands to reduce the pollution potential of runoff and wastewater average $7,724/acre where natural regeneration of wetland plants will be a major contributor to the working vegetation and $10,286/acre where wetland vegetation in the pool area is planted at a denser grid (3-foot by 3-foot or closer). As needed, embankments, water control and grade stabilization structures, and filter strips should be added.

3.10.5 Streambank Stabilization/Erosion Controls

Streambank stabilization and erosion control measures will vary greatly in cost and EQIP payment and may cover a variety of techniques. Costs may be as low as $38/cubic yard for full bank armor on the streambank, including earthwork, rip rap (in which loose stone is used for bank stability), and/or geotextile (which is permeable fabric that helps reinforce streambanks). Alternatively, costs may be as high as $53/linear foot for bank protection using peaked stone toes (stones placed to secure the lower portion of a streambank), stream barbs (rock sills projecting out from a streambank, meant to redirect flow away from an eroding bank), and/or bendway weirs (low level rock dikes angled upstream, altering the stream's secondary currents and controlling excessive channel deepening) (NRCS 2016).

Alternatively, turf reinforcement mats (TRMs) may be used to reinforce vegetation and protect soil from erosion. TRMs are protective reinforced materials formed into a non-degradable mat, and may be appropriate where vegetation alone will not sustain long term erosion protection, and where other options may be limited due to landscape features such as mowing, which may be prominent in the Thorn Creek watershed (AISWCD 2013b). Implementation of TRMs may cost approximately $0.60/square foot, or to $26,136/acre (NRCS 2016), and can be as little as one-third the cost of rip rap (Pack 2008). Prices vary greatly and are dependent upon the steepness of the slope that is being treated, and the vegetation and anchor types being used, which are dependent upon the expected velocities that the TRMs will be expected to withstand (Propex 2007).

Additionally, conservation cover may be implemented and may range in price from $583.66/acre to $1,243.89/acre. Conservation cover involves the establishment of permanent vegetation cover, and costs are dependent on the type of vegetation, whether or not organic seed is used, and the ecosystem type into which the vegetation is being introduced (NRCS 2016).

3.10.6 Vegetated Swales

Vegetated swales vary in size and may include checks, depending upon the slope of the area in question. Costs and EQIP payments range from $2,569/acre for a vegetated swale with a top width less than 35 feet and no checks, to $4,015/acre for a vegetated swale with a top width greater than 55 feet and with checks (NRCS 2016).

3.10.7 Green Roofs

Green roofs are relatively new technology in the United States and costs are estimated to average between $15/square foot to $20/square foot. These cost estimates are for all use types; i.e., high density residential, commercial, and industrial (Urban Design Tools 2016).

3.10.8 Bio-Retention Cells

Bio-retention cells, otherwise known as rain gardens, range in cost depending upon the permeability of the soil and the vegetation types used within the cell. Where highly permeable soils are present, costs range from $1.50 to $3.00/square foot. Where soils are less permeable, costs may range from $4.00 to $6.00/square foot (Penn State Extension 2016).

3.10.9 Conservation Tillage

Conservation tillage is assumed to include tillage practices that preserve at least 30 percent residual cover of the soil after crops are planted. Costs associated with converting to conservation tillage will depend on the extent and degree of conservation tillage practices implemented. A no-till/strip-till system, organic or non-organic, involves managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while limiting soil-disturbing activities used to grow and harvest crops. These systems average approximately $16/acre. Incorporating mulch till in place of conventional till costs $4.21/acre, and applies to both organic and conventional fields. A full-width ridge-till system costs approximately $30/acre. Contour farming is a practice in which row orientation is changed from up and down hill orientation to nearly perpendicular to the flow of runoff. Costs for this practice are $6.06/acre.

3.10.10 Septic System Maintenance

Septic tanks are designed to accumulate sludge in the bottom portion of the tank while allowing water to pass into the drain field. If the tank is not pumped out regularly, the sludge can accumulate and eventually become deep enough to allow for flow into the drain field. Pumping the tank every three to five years prolongs the life of the system by protecting the drain field from solid material that may cause clogs and system back-ups. In addition, septic systems should not be connected to field tile lines.

The cost to pump a typical septic tank ranges from $250 to $350 depending on how many gallons are pumped out and the disposal fee for the area. If a system is pumped once every three to five years, this expense averages out to less than $100 per year.

The cost of developing and maintaining a watershed-wide database of the onsite wastewater treatment systems in the Thorn Creek watershed depends on the number of systems that need to be inspected and the means by which the systems are inventoried. Education of home and business owners that use onsite wastewater treatment systems should occur periodically. Public meetings; mass mailings; and radio, newspaper, and TV announcements can all be used to remind and inform owners of their responsibility to maintain their systems. The costs associated with education and inspection programs will vary depending on the level of effort required to communicate the importance of proper maintenance and the number of systems in the area. It is unknown at this time how many septic systems are present within the watershed. As noted in **Section 3.7.2**, the entirety of the watershed is currently within the service area of a municipal sewer system. If functional or abandoned septic systems still exist within the watershed, these are expected to be limited in number.

3.11 Information and Education

Public education and participation is a key factor for TMDL and watershed plan implementation. Increased public awareness can increase implementation of BMPs. Small incremental improvements and individual adoption of BMPs can be achieved at a much lower cost compared to the large-scale BMPs identified above. Outreach and education efforts should focus on activities that support the watershed plan goals, including:

- Native landscaping
- Biological and water quality monitoring
- Lake and stream management
- Encouraging native landscaping, including buffers along lakeshores and streambanks
- Buffer strips
- Reducing the use of lawn chemicals (pesticides and phosphorus fertilizers)
- Water conservation
- Green infrastructure

An additional public meeting will be held within the watershed to present the final TMDL results and the implementation plan. Additional recommended activities to support public outreach and education include:

- Websites and social media to publicize meetings, upcoming events, and links to resources
- E-mail updates
- Brochures with information on household pollutant reduction, rain gardens, and fertilizer use
- Educational signs to educate viewers on water quality issues, purpose of BMPs, and environmental stewardship
- Public service announcements

3.12 Ongoing Activities

A number of watershed restoration projects are currently underway in the Thorn Creek Watershed. The following lists some of the recent activities as well as ongoing water quality programs which show a commitment to improving water quality conditions within the watershed. Please contact the supporting entities for additional information on projects currently underway in the watershed.

- **Will Center Road Storm Sewer Outfall Improvements- Village of University Park, Crete-Monee School District, the Forest Preserve District of Will County, and CMT Engineers.** An award-winning infiltration and wetland concept was developed into a green sustainable solution that provides an improvement in run-off water quality, a reduction of water quantity, and a wetland amenity, while protecting the headwaters of Thorn Creek.
- **Thorn Creek Headwaters Wetland Mitigation – Forest Preserve District of Will County and the Illinois Department of Transportation (IDOT).** Restoration of 92 acres of the Thorn Creek Headwaters to provide wetland mitigation credits for IDOT and help achieve restoration goals in the Headwaters area. The project includes drain tile disablement, selective tree and shrub removal, planting native seed, plants, and trees, invasive species control, mowing and prescribed fire to restore and enhance a wetland area. This effort will provide water quality benefits to the upper most reaches of Thorn Creek.
- **Thorn Creek Greenway Preserve Improvement and Management Plan – Forest Preserve District of Will County.** A 2014 guiding document for future planning, improvement, management, restoration and operation of District preserves and greenways. The plan is designed to provide and enhance recreational, ecological, and educational opportunities within the Preserve that contribute to the public appreciation of natural history and the environment.

3.13 Project Funding

Cost-share programs and low-interest loans at the local, state and federal level are available to municipalities, landowners, and homeowners in the watershed to help offset costs of implementing many of the BMPs recommended in this plan. Many involve cost sharing, and some may allow the local contribution of materials, land, and in-kind services (such as construction and staff assistance) to cover a portion or the entire local share of the project. Several of these programs are presented below. In addition to these programs, partnerships between local governments can help to leverage funds. A stormwater utility may also be used to generate local funds for stormwater programs and are becoming more common.

3.13.1 Available State-Level Programs for Nonpoint Sources

The following paragraphs describe a few state-level programs designed to encourage landowners to implement resource-conserving practices for water quality and erosion control purposes. Municipalities should aim to incorporate the recommendations of this plan into their annual budgets and comprehensive improvement plans. In general, the majority of funds should come from local efforts; however, the Illinois EPA does offer grants to control nonpoint source pollution in the state. These grants are available to local governments, as well as to other organizations for the purpose of protecting water quality. Projects must address water quality issues relating directly to nonpoint source pollution, and funds can be used to develop, update, and implement watershed management plans. This includes the development of information and education programs, as well as the installation of BMPs.

3.13.1.1 The Conservation Fund

The Conservation Fund, an environmental non-profit, provides low-interest land conservation loans for a variety of conservation projects. Under this fund, land in the Thorn Creek watershed could be converted to green space, providing land for potential wetlands, filter strips, and riparian buffers, and thereby improving water quality (The Conservation Fund 2016).

3.13.1.2 Partners for Conservation

In 1995 the Illinois General Assembly passed the Conservation 2000 bill providing $100 million in funding over a 6-year period for the promotion of conservation efforts. In 1999, legislation was passed to extend the program through 2009. In 2008, House Bill 1780 was signed into law as Public Act 95-0139, extending the program to 2021 as Partners for Conservation. The Partners for Conservation Program funds programs at Illinois Department of Natural Resources, IDA, and Illinois EPA. Its programs include:

- **Conservation Practices Cost-Share Program:** This program provides monetary incentives for conservation practices implemented on land eroding at a rate of one and one-half times or more the tolerable soil loss rate. Payments of up to 60% of initial costs are paid through the local conservation districts, which also prioritize and select the projects to be funded in their district. The program provides cost share assistance for BMPs such as cover crops, filter strips, grassed waterways, no-till systems, pasture planting, contour farming, and installation of stormwater ponds. Practices funded through this program must be maintained for at least 10 years. More information can be found at https://www.agr.state.il.us/conservation/.

- **Streambank Stabilization Restoration Program**: The Streambank Stabilization and Restoration Program (SSRP) was established to address problems associated with streambank erosion, such as loss or damage to valuable farmland, wildlife habitat, and roads; stream capacity reduction through sediment deposition; and degraded water quality, fish, and wildlife habitat. The primary goals of the SSRP are to develop and demonstrate vegetative, stone structure, and other low cost bio-engineering techniques for stabilizing streambanks and to encourage the adoption of low-cost streambank stabilization practices by making available financial incentives, technical assistance, and educational information to landowners with critically eroding streambanks. A cost share of 75 percent is available for approved project components such as willow post installation, bendway weirs, rock riffles, stream barbs/rock, vanes, lunker structures, gabion baskets, and stone toe protection techniques. There is no limit on the total program payment for cost-share projects that a landowner can receive in a fiscal year; however, maximum cost per foot of bank treated is used to cap the payment assistance on a per foot basis and maintain the program's objectives of funding low-cost techniques (IDA 2000). All project proposals must be sponsored and submitted by the local Soil and Water Conservation District (SWCD) and recipients of program funding must agree to maintain the implemented practices for at least 10 years. Further information is available at https://www.agr.state.il.us/conservation/.

- **Sustainable Agriculture Grant Program:** This program funds on-farm and university research, education, and outreach efforts for sustainable agricultural practices. Private landowners, organizations, educational, and governmental institutions are all eligible for participation in this program. Maximum per-project, per-year grant amounts are $10,000 for individuals and $20,000 for units of government, non-profits, institutions or organizations, and a source of matching funds is required. More information can be found at https://www.agr.state.il.us/conservation-2000.

3.13.1.3 State Revolving Fund

The State Revolving Fund programs, including the Water Pollution Control Loan Program for wastewater and stormwater projects and the Public Water Supply Loan Program for drinking water projects, are annually the recipients of federal capitalization funding, which is combined with state matching funds and program repayments to form a perpetual source of low interest financing for environmental infrastructure projects. Eligible projects include traditional pipe, storage, and treatment systems, green infrastructure projects, erosion and sediment control projects, and ROW acquisition needed for such projects. The loans are for a maximum of 20 years, and can be used to cover the entire project cost. Recent projects obtained loans for between several hundred thousand dollars and nearly one hundred million dollars. More information about this fund can be found at http://www.epa.illinois.gov/topics/grants-loans/state-revolving-fund/index.

3.13.1.4 Ag Invest Agricultural Loan Program – Annual or Long Term

The Ag Invest Agricultural Loan Program offered through the Illinois State Treasury office provides low-interest loans to assist farmers. Loan funds can be used to implement soil and water conservation practices, for construction related expenses, to purchase farm equipment, or to pay for costs related to traditional crop production and alternative activities. Loan limits are between $300,000 and $400,000 per year. More info is available at http://illinoistreasurer.gov/Individuals/Ag_Invest.

3.13.1.5 Illinois Buffer Partnership

The Illinois Buffer Partnership is administered by Trees Forever, an Iowa non-profit organization. It offers cost sharing for installation of streamside buffer plantings at selected sites. Ten to twenty participants in Illinois are selected for the program annually. They receive cost-share assistance, onsite assistance from Trees Forever field staff, project signs, and the opportunity to host a field day to highlight their project. Participants are reimbursed up to $2,000 for 50% of the expenses remaining after other grant programs are applied. Types of conservation projects eligible for the Illinois Buffer Partnership program include: riparian buffers, livestock buffers, streambank stabilization projects, wetland development, pollinator habitat, rain gardens, and agroforestry projects. More information can be found at http://treesforever.org/Illinois_Buffer_Partnership.

3.13.1.6 Illinois Department of Agriculture and Illinois EPA Nutrient Management Plan Project

The IDA and Illinois EPA co-sponsor a cropland Nutrient Management Plan project in watersheds that have developed or are developing TMDLs. This voluntary project supplies incentive payments to producers to have NMPs developed and implemented. Additionally, watersheds that have sediment or phosphorus identified as a cause for impairment (as is the case in this watershed), are eligible for cost-share assistance in implementing traditional erosion control practices through the Nutrient Management Plan project.

3.13.1.7 Vegetative Filter Strip Assessment Law

The Vegetative Filter Strip Assessment Law (35 ILCS 200/10-152), sometimes called the Tax Incentive Filter Strip Program, is a state program that protects water quality by providing a property tax reduction incentive to landowners who install vegetative filter strips between farm fields and an area to be protected, including but not limited to surface water, a stream, or a sinkhole. The filter strips must meet NRCS standards and specifications.

In counties with less than 3,000,000 inhabitants, landowners may receive a reduced property tax assessment of 1/6th of the strip area's productivity value as cropland. In counties with 3,000,000 or more inhabitants, the land shall be valued at the lesser of either 16% of the fair cash value of the farmland estimated at the price it would bring at a fair, voluntary sale for use by the buyer as a farm or 90% of the 1983 average equalized assessed value per acre certified by the Department of Revenue. Landowners can expect to save about $1 to $25 per acre in taxes depending on soils and local tax rates. Vegetative filter strip design and certification assistance is available from local SWCD offices.

3.13.2 Available Federal-Level Programs for Nonpoint Sources

There are several voluntary conservation programs established by various federal agencies that encourage landowners to implement resource-conserving practices for water quality and erosion control purposes. Federal-level programs are discussed in the following paragraphs. The USEPA manages the Clean Water Act Section 319 Grants. The Farm Service Agency (FSA) oversees the Conservation Reserve Program (CRP). Voluntary conservation programs established through the 2014 U.S. Farm Bill, and managed by the NRCS, include the Agricultural Conservation Easement Program (ACEP), the Conservation Stewardship Program (CSP), and the Environmental Quality Incentives Program (EQIP).

3.13.2.1 Clean Water Act Section 319 Grants

Section 319 was added to the CWA to establish a national program to address nonpoint sources of water pollution. Through this program, each state is allocated Section 319 funds on an annual basis according to a national allocation formula based on the total annual appropriation for the section 319 grant program. The total award consists of two categories of funding: incremental funds and base funds. A state is eligible to receive USEPA 319(b) grants upon the USEPA's approval of the state's Nonpoint Source Assessment Report and Nonpoint Source Management Program. States may reallocate funds through sub-awards (e.g., contracts, sub-grants) to both public and private entities, including local governments, tribal authorities, cities, counties, regional development centers, local school systems, colleges and universities, local nonprofit organizations, state agencies, federal agencies, watershed groups, for-profit groups, and individuals.

USEPA designates incremental funds, a $163-million award in 2016, for the restoration of impaired water through the development and implementation of watershed-based plans and TMDLs for impaired waters. Base funds, funds other than incremental funds, are used to provide staffing and support to manage and implement the state Nonpoint Source Management Program. Section 319 funding can be used to implement activities which improve water quality, such as filter strips, streambank stabilization, etc. (USEPA 2003).

Illinois EPA receives federal funds from USEPA through section 319(h) of the CWA to help implement Illinois' Nonpoint Source Pollution Management Program. The purpose of the program is to work cooperatively with local units of government and other organizations toward the mutual goal of protecting the quality of water in Illinois by controlling nonpoint source pollution. The program emphasizes funding for implementing cost-effective corrective and preventative BMPs on a watershed scale; funding is also available for BMPs on a non-watershed scale and the development of information/education nonpoint source pollution control programs.

The maximum federal funding available is 60% of the total cost, with the remaining 40% coming from local match. The program period is two years unless otherwise approved. Approximately $3,000,000 is available in this program per year, awarded amongst approximately 15 projects.

Projects or activities carried out to comply with the six MS4 minimum control measures are not eligible for section 319 funding. However, there may be some activities that promote opportunities to implement the watershed approach that are eligible for section 319 funding that could indirectly address the six minimum measures as well as nonpoint source projects. For more information: http://www.epa.state.il.us/water/watershed/nonpoint-source.html..

3.13.2.2 Wetland Program Development Grants

The USEPA provides wetland program development grants to assist state, tribal, and local government agencies, as well as interstate/intertribal entities, in building programs to protect, manage, and restore wetlands (USEPA 2016b).

3.13.2.3 Rivers, Trails, and Conservation Assistance

The National Park Service (NPS) provides financial assistance for the development of natural resource conservation programs, aimed at designing trails and parks, improving access to rivers, protecting special places, and creating recreation opportunities. Applicants may include state and local agencies, tribes, nonprofit organizations, or citizen groups (NPS 2016).

3.13.2.4 Conservation Reserve Program

The CRP may apply to the portion of the Thorn Creek watershed that is agricultural. The CRP is a voluntary program, administered through the FSA, which encourages landowners to agree to remove environmentally sensitive land from agricultural production and plant long-term resource-conserving cover to improve water quality, prevent soil erosion, and reduce loss of wildlife habitat.

Participants can enroll in CRP in two ways and the duration of the contracts under CRP range from 10 to 15 years. The first enrollment method is through a competitive process known as the CRP General Sign-up. These are announced on a periodic basis by the Secretary of Agriculture but do not occur on any fixed schedule. The second enrollment method is through CRP Continuous Sign-up, which is offered on a continuous basis. Continuous sign-up provides management flexibility to farmers and ranchers to implement certain high-priority conservation practices on eligible land. All enrollment offers are processed through the local FSA office.

Certain conditions must be met in order for land to be eligible for CRP enrollment. These conditions include the following:

1. The farmer applying for enrollment must have owned or operated the land for at least 12 months prior to the previous CRP sign-up period (except in cases of a change in ownership due to the previous owner's death, foreclosure, or land purchase by the new owner without the sole intention of placing it in the CRP).

2. Cropland that is planted or considered planted to an agricultural commodity for four of the six most recent crop years (including field margins) and must be physically and legally capable of being planted in a normal manner to an agricultural commodity.

3. Certain marginal pastureland suitable for use as any of the following conservation practices: buffer for wildlife habitat, wetlands buffer or restoration, filter strips, riparian buffer, grass waterway, shelter belt, living snow fence, contour grass strip, salt tolerant vegetation, or shallow water area for wildlife.

In addition to the eligible land requirements, cropland must meet one of the following criteria:

- Have a weighted average erosion index of 8 or higher
- Be expiring CRP acreage
- Be located in a national or state CRP conservation priority area.

The FSA bases rental rates on the relative productivity of soils within each county and the average dryland cash rent or cash-rent equivalent. The maximum rental rate for each offer is calculated in advance of enrollment. Producers may offer land at the maximum rate or at a lower rental rate to increase likelihood of offer acceptance. In addition, the FSA provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices (USDA 2016: https://www.fsa.usda.gov/programs-and-services/conservation-programs/prospective-participants/index). CRP annual rental payments may include an additional amount up to $2 per acre per year as an incentive to perform certain maintenance obligations (up to $7 for certain continuous sign-up practice).

Finally, the FSA offers additional financial incentives for certain continuous sign-up practices. Signing Incentive Payment is a one-time incentive payment of $10/acre for each acre enrolled for each full year of the contract. Eligible practices include field windbreaks; grassed waterways; shelter belts; living snow fences; filter strips; riparian buffers; marginal pastureland wildlife and wetland buffers; bottom timber establishment; field borders; longleaf pine establishment; duck nesting habitat; SAFE buffers, wetlands, trees, longleaf pine, and grass; pollinator habitat; and several wetlands practices. The Performance Incentive Payment is a one-time incentive payment made to participants who enroll land in CRP to be devoted to all continuous sign up practices except establishment of permanent vegetative cover on terraces, wetland restoration (including non-floodplain), bottomland timber establishment, and duck nesting habitat.

The maximum annual non-cost share payment that an eligible "person" can receive under the CRP is $50,000 per fiscal year. This is a separate payment limitation applying only to CRP non-cost share payment.

3.13.2.5 Conservation Stewardship Program

The CSP may also apply to the portion of the Thorn Creek watershed that is agricultural. The CSP is for agricultural producers who want to maintain or improve existing conservation practices on their land as well as adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment.

Through CSP, participants take additional steps to improve resource conditions including soil quality, water quality and quantity, air quality, habitat quality, and energy. CSP provides two types of payments through 5-year contracts: annual payments for installing new conservation activities and maintaining existing practices; and supplemental payments for adopting a resource-conserving crop rotation. Producers may be able to renew a contract if they have successfully fulfilled the initial contract and agree to achieve additional conservation objectives. Payments are made soon as practical after October 1 of each fiscal year for contract activities installed and maintained in the previous year. In fiscal year 2016, NRCS made $150 million available for producers through the CSP.

Eligible lands include private and Tribal agricultural lands, cropland, grassland, pastureland, rangeland and non-industrial private forest land. CSP is available to all producers, regardless of operation size or type of crops produced, in all 50 states, the District of Columbia, and the Caribbean and Pacific Island areas. Applicants may include individuals, legal entities, joint operations, or Indian tribes that meet the stewardship threshold for at least two priority resource concerns when they apply. They must also agree to meet or exceed the stewardship threshold for at least one additional priority resource concern by the end of the contract. Producers must have effective control of the land for the term of the proposed contract, which include all eligible land in the agricultural operation. Some additional restrictions and program requirements may apply and interested applicants should contact the local NRCS office for more information. More information about the CSP can be found at https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/.

3.13.2.6 Sustainable Agricultural Grant Program (SARE)

SARE is a U.S. Department of Agriculture program that funds research, education, and outreach efforts for sustainable agricultural practices. Farmer Rancher Grants are for farmers and ranchers who want to explore sustainable solutions to problems through on-farm research, demonstration, and education projects. These grants have funded a variety of topics including pest/disease management, crop and livestock production, education/outreach, networking, quality of life issues, marketing, soil quality, energy, and more. Awards are for a maximum of $7,500 for an individual project to a maximum of $22,500 for a group project, and may last up to 24 months. No matching funds are required for this program. About 40 Farmer Rancher grant projects are funded nationwide each year. More information is at http://www.sare.org/Grants.

3.13.2.7 Agricultural Conservation Easement Program

ACEP provides financial and technical assistance to help landowners protect, restore, and enhance agricultural and wetlands on their property. Land can be placed into an agricultural land easement or wetland reserve easement. The Agricultural Land Easements component of ACEP has limited applicability to the Thorn Creek watershed but may apply in the approximately 19% that is agricultural. Under the Agricultural Land Easements component, NRCS helps American Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Land protected by agricultural land easements provides additional public benefits, including environmental quality, historic preservation, wildlife habitat, and protection of open space. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect, and enhance enrolled wetlands. Wetland Reserve Easements provide habitat for fish and wildlife, including threatened and endangered species, improve water quality by filtering sediments and chemicals, reduce flooding, recharge groundwater, protect biological diversity and provide opportunities for educational, scientific and limited recreational activities.

Agricultural Land Easements: NRCS provides financial assistance to eligible partners purchase Agricultural Land Easements that protect the agricultural use and conservation values of eligible land. In the case of working farms, the program helps farmers and ranchers keep their land in agriculture. The program also protects grazing uses and related conservation values by conserving grassland, including rangeland, pastureland and shrubland. Land eligible for agricultural easements includes cropland, rangeland, grassland, pastureland and non-industrial private forest land. NRCS will prioritize applications that protect agricultural uses and related conservation values of the land and those that maximize the protection of contiguous acres devoted to agricultural use.

To enroll land through agricultural land easements, NRCS enters into cooperative agreements with eligible partners. Each easement is required to have an agricultural land easement plan that promotes the long-term viability of the land. Under the Agricultural Land component, NRCS may contribute up to 50% of the fair market value of the agricultural land easement. Where NRCS determines that grasslands of special environmental significance will be protected, NRCS may contribute up to 75 percent of the fair market value of the agricultural land easement.

Wetland Reserve Easements: NRCS also provides technical and financial assistance to restore, protect, and enhance wetlands through the purchase of a wetland reserve easement. These agreements include the right for NRCS to develop and implement a wetland reserve restoration easement plan to restore, protect, and enhance the wetland's functions and values. Land eligible for wetland reserve easements includes farmed or converted wetland that can be successfully and cost-effectively restored. NRCS will prioritize applications based the easement's potential for protecting and enhancing habitat for migratory birds and other wildlife. For acreage owned by an Indian tribe, there is an additional enrollment option of a 30-year contract. Through the wetland reserve enrollment options, NRCS may enroll eligible land through one of the following:

- Permanent Easements – These are conservation easements in perpetuity. NRCS pays 100 percent of the easement value for the purchase of the easement. Additionally, NRCS pays between 75 to 100 percent of the restoration costs.
- 30-year Easements – These expire after 30 years. Under 30-year easements, NRCS pays 50 to 75 percent of the easement value for the purchase of the easement. Additionally, NRCS pays between 50 to 75 percent of the restoration costs.
- Term Easements – Term easements are easements made for the maximum duration allowed under applicable State laws. NRCS pays 50 to 75 percent of the easement value for the purchase of the term easement. Additionally, NRCS pays between 50 to 75 percent of the restoration costs.
- 30-year Contracts – 30-year contracts are only available to enroll acreage owned by Indian tribes, and program payment rates are commensurate with 30-year easements.

For wetland reserve easements, NRCS pays all costs associated with recording the easement in the local land records office, including recording fees, charges for abstracts, survey and appraisal fees, and title insurance.

Wetland Reserve Enhancement Partnership – The 2014 Farm Bill replaced the Wetland Reserve Enhancement Program with the Wetland Reserve Enhancement Partnership (WREP) as an enrollment option under ACEP. WREP continues to be a voluntary program through which NRCS signs agreements with eligible partners to leverage resources to carry out high priority wetland protection, restoration, and enhancement and to improve wildlife habitat.

- Partner benefits through WREP agreements include:
  - Wetland restoration and protection in critical areas
  - Ability to cost-share restoration or enhancement beyond NRCS requirements through leveraging
  - Able to participate in the management or monitoring of selected project locations
  - Ability to use innovative restoration methods and practices

In 2016, NRCS made $15 million in financial and technical assistance available to help eligible conservation partners leverage local resources to voluntarily protect, restore, and enhance critical wetlands on private and tribal agricultural land nationwide. The funding is provided through the WREP, a special enrollment option under the Agricultural Conservation Easement Program. To enroll, land eligible partners may submit proposals to the local NRCS office. More information is available at https://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/easements/acep/.

3.13.2.8 Environmental Quality Incentive Program

EQIP is a voluntary program that provides financial and technical assistance to eligible producers to plan and implement conservation practices that improve soil, water, plant, animal, air, and related natural resources on eligible land, including non-industrial private forestland. Conservation practices eligible for EQIP funding which are recommended BMPs for this watershed include BMPs such as filter strips, riparian buffers, vegetated swales (grass waterways), streambank/shoreline protection, and wetland restoration. More information regarding state and local EQIP implementation can be found at http://nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/. One example in Illinois of the use of EQIP funds in an urbanized area includes a site near East Peoria, where EQIP funds were used prior to site development for the construction of two ponds to include spillway construction, seeding, and mulching (AISWCD 2002).

Under the EQIP program are Conservation Innovation Grants. These grants are anticipated to be available for use by the broader public to leverage federal investment, stimulate innovative approaches, and accelerate technology transfer. Any development proposal that could incorporate conservation BMPs could potentially be eligible under this program. Developers who need to meet local development requirements mandating groundwater protection, buffers and stormwater detention, could utilize this program to help offset implementation costs.

Through EQIP, the NRCS develops contracts with eligible producers to implement conservation practices to address environmental natural resource problems. Persons interested in entering into a cost-share agreement with the NRCS for EQIP assistance may file an application at any time; however, each state may establish deadlines for one or more application periods in which to consider eligible applications for funding. Applications submitted after the deadlines will be evaluated and considered for funding during later funding opportunities.

Most contracts are for one to three years. EQIP provides payments up to 75 percent of the incurred costs on eligible conservation practices and activities. Payments received by producers through EQIP contracts after February 7, 2014 may not exceed $450,000 for all EQIP contracts entered into during the period from 2014 to 2018. Payment limitations for organic production may not exceed an aggregate $20,000 per fiscal year or $80,000 during any 6-year period for installing conservation practices.

3.13.3 Local Program Contact Information

The Thorn Creek watershed is found in eastern Will County and southern Cook County. This area is served by a single office. Local contact information for the office is listed in **Table 3-7** below.

Table 3-7: Local SWCD and NRCS Contact Information

County	Address	Phone
Will County and South Cook County	1201 S. Gouger Rd New Lenox, IL 60451	(815) 462-3106

3.14 Planning Level Cost Estimates for Implementation Measures

Cost estimates for different implementation measures are presented in **Table 3-8**. The column labeled "Program" or "Sponsor" lists the financial assistance program or sponsor available for various BMPs (as discussed in **Section 3.12**). Illinois EPA 319 Grants are applicable to all of the practices.

Table 3-8: Cost Estimates of Various BMP Measures

BMP	Units	Installation Cost	Program	Sponsor(s)
Filter strip (seeded)	per acre	\$520 - \$639	EQIP	NRCS, IDA
Riparian buffer – bare-root trees/shrubs	each	\$1.10 - \$1.65	EQIP	NRCS, IDA
– forested	per acre	\$741		
– herbaceous cover	per acre	\$642		
– land preparation	per acre	\$38		
Nutrient management	per acre	\$13 - \$45	EQIP	NRCS
Nutrient management plan – federal	per acre	\$1,740 - \$2,902	EQIP	NRCS
– state	per acre	\$13	NMP Project	IDA, Illinois EPA
Bank stabilization	per ft.	\$27 - \$52	SSRP	IDA
– weirs/rock riffles	each	\$2,448 - \$6,305		
– stream barb/bendway weir with longitudinal peaked stone toe	per ft.	\$27.27 - \$52.50		
– bank armor	per c.y.	\$37.55		
Vegetated swales	per acre	\$2,569 - \$4,015	EQIP	IDA NRCS
– <35 ft top width	per acre	\$2,569		
– <35 ft top width, with checks	per acre	\$3,284		
– 35-55 ft top width	per acre	\$2,709		
– 35-55 ft top width, with checks	per acre	\$3,516		
– >55 ft top width	per acre	\$3,253		
– >55 ft top width, with checks	per acre	\$4,015		
Wetland – enhancement/restoration	per acre	\$1,167 - \$3,680	ACEP	NRCS
– constructed	per acre	\$7,725 - \$10,286		
Green roofs	per SF	\$15 - \$20		
Bio-retention cell – high permeability soils	per SF	\$1.50 - \$3.00		
– low permeability soils	per SF	\$4.00 - \$6.00		

BMP	Units	Installation Cost	Program	Sponsor(s)
Conservation tillage			EQIP	NRCS, IDA
– no-till/strip-till	per acre	$16		
– mulch-till	per acre	$4.21		
– ridge-till	per acre	$30		
Contour farming	per acre	$6.06	EQIP	NRCS
Septic system maintenance	per event	$250 - $350	Private system owner	

ac = acre
ft = foot
CY = cubic yard
SF = square foot

3.15 Milestones and Monitoring

3.15.1 Interim Measurable Milestones and Schedule

Successful plan implementation relies on establishing and tracking milestones to measure progress. **Table 3-9** below identifies these milestones and a schedule for meeting each milestone. Stakeholders should evaluate milestone progress on an annual basis and implement adaptive management to modify management measures, milestones, and schedule as necessary.

Implementation of the management actions outlined in this section should occur in phases, often over the course of several years, with effectiveness assessments made as improvements are completed. The process of obtaining funding, and developing and implementing projects designed to improve water quality, can take months or years to complete and once in place, improvements in water quality as a result of BMPs may not be detectable for several years. Continued monitoring and reevaluation of the implementation measures during this time will allow for more expedient adjustment to BMP implementation measures that may result in earlier attainment of water quality targets.

Table 3-9: Implementation Milestones

Milestones	Description	Estimated Schedule
Funding	Develop grant applications	Short term: 2-5 years
Implement Short-term Projects	Identify and implement short-term pilot projects that can be completed (i.e. willing landowners and available funding)	Mid-term: 2-5 years
Monitoring	Implement monitoring plan	Continuous: 1-20 years
Annual Stakeholder meetings	Stakeholders will convene at once a year to gauge progress and discuss evolving needs and planned activities	Annually
Implement Larger Projects	Identify and implement larger projects. These projects are more likely to have multiple funding sources and stakeholders.	Mid- Term: 5-10 years
Education and outreach	Prepare and implement and education and outreach plan. Conduct at least two public meetings annually.	Continuous: 1-20 years

3.15.2 Monitoring Plan

The purpose of the monitoring plan for the Thorn Creek watershed is to assess the overall implementation of management actions outlined in this section. This can be accomplished by conducting the monitoring programs designed to:

- Track implementation of BMPs in the watershed
- Estimate effectiveness of BMPs
- Further monitor of point source discharges in the watershed
- Continued monitoring of impaired lakes, stream segments, and tributaries
- Monitor storm-based high flow events
- Low flow monitoring of total phosphorus, chloride, zinc, silver, DO, TSS, and fecal coliform in impaired streams and Sauk Trail Lake
- Dry weather monitoring of stormwater outfalls

Tracking the implementation of management measures can be used to:

- Determine the extent to which management measures and practices have been implemented compared to action needed to meet the TMDL endpoints
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation efforts
- Measure the extent of voluntary implementation efforts
- Support work-load and costing analysis for assistance or regulatory programs
- Determine the extent to which management measures are properly maintained and operated

Estimating the effectiveness of the BMPs implemented in the watershed could be completed by monitoring before and after the BMP is incorporated into the watershed. Additional monitoring could be conducted on specific structural systems such as a sediment control basin. Inflow and outflow measurements could be conducted to determine site-specific removal efficiency.

Illinois EPA conducts Intensive Basin Surveys every 5 years. Additionally, select ambient sites are monitored nine times a year. Continuation of this state monitoring program will assess lake and stream water quality as improvements in the watershed are completed. This data will also be used to assess whether water quality standards in the impaired segments are being attained.

3.15.3 Success Criteria

Measuring the plan's success depends largely on tracking the milestones outlined above. Implementing BMPs should equate to improved water quality and attainment of designated uses and water quality standards. Monitoring pollutant-load reductions will be the primary success criteria. Key components include:

- Securing funding for priority projects within 5 years
- Meeting milestones identified
- Meeting 25-50% of target reductions within 10 years
- Meeting 100% of target reductions within 20 years
- Utilizing adaptive management to ensure best practices
- Delisting of impaired waterbodies

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Section 4
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Appendix A

Historical Water Quality Data

Draft appendices are available by request.
Contact Mr. Abel Haile at (217) 782-3362.

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Appendix B

QUAL2K Model Files

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Appendix C

Load Duration Curve Analyses

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Appendix D

BATHTUB Model Files

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Appendix E

Acute and Chronic Zinc Standards Calculations

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